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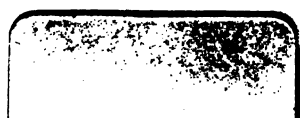
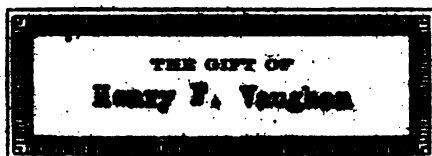
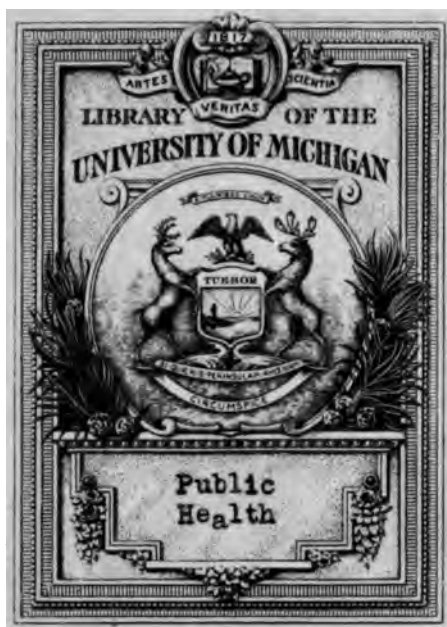
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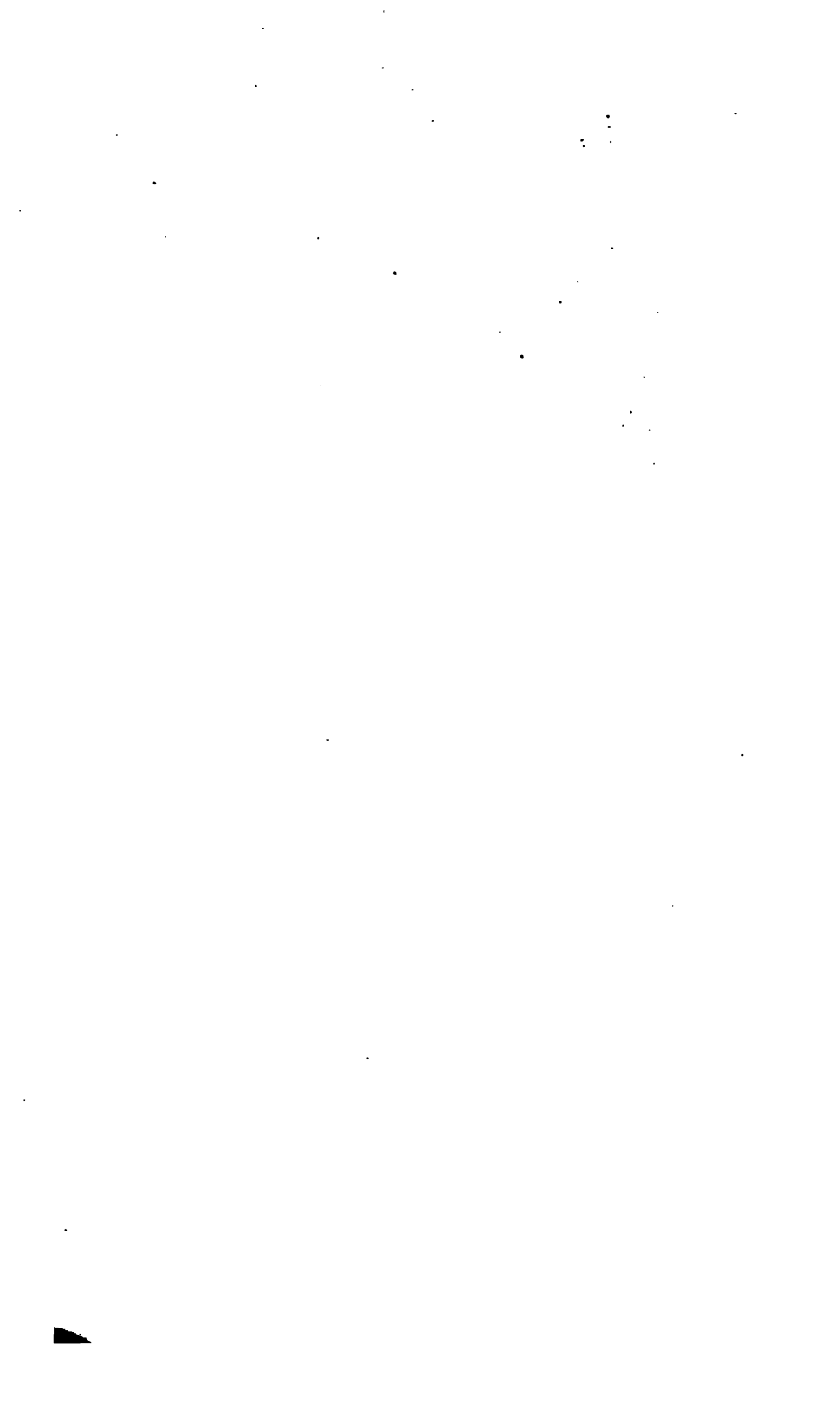
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TWENTY-FIFTH ANNUAL REPORT

OF THE

STATE BOARD OF HEALTH

OF

MASSACHUSETTS.

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1894.



## MEMBERS OF THE BOARD.

1893-1894.

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*Secretary.*

SAMUEL W. ABBOTT, M.D.

*Engineer.*

F. P. STEARNS, C.E.

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\* Died November, 1893.



Public Health

gt.  
Henry F. Vaughan

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# GENERAL REPORT.

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The following report comprises the general work of the State Board of Health of Massachusetts for the year ending Sept. 30, 1893.

The following are the subjects embraced in this report : —

REPORT TO THE LEGISLATURE UPON WATER SUPPLY AND SEWERAGE, INCLUDING THE ADVICE OF THE BOARD GIVEN UNDER THE PROVISIONS OF CHAPTER 375 OF THE ACTS OF 1888.

SUMMARY OF WEEKLY MORTALITY RETURNS FROM CITIES AND TOWNS.

REPORTS OF INFECTIOUS DISEASES.

REPORTS UPON FOOD AND DRUG INSPECTION.

INFECTIOUS DISEASE HOSPITALS.

HEALTH OF TOWNS.

The following members comprised the Board in 1893 : —

HENRY P. WALCOTT, *Chairman*.

FRANK W. DRAPER.

HIRAM F. MILLS.

ELIJAH U. JONES.

JOSEPH W. HASTINGS.

GERARD C. TOBEY.

MORRIS SCHAFF.

J. H. Raymond resigned in January, and G. C. Tobey of Wareham was appointed in his place.

General Schaff resigned in August, 1893, and J. W. Hull of Pittsfield was appointed in his place.

Dr. Elijah U. Jones of Taunton died in November, 1893. He had been a member of the Board since its reorganization in 1886, and had taken a deep and continued interest in the work of the Board from the beginning of his connection with it.

C. H. Porter of Quincy was appointed in February, 1894, to fill the place made vacant by the death of Dr. Jones.



From these notices the following statistics are compiled for the nine years ending with 1893 :—

*Small-pox in Massachusetts, 1885-1893.*

| YEARS.    | SMALL-POX.   |               |           | VACCINATED. |         |           | UNVACCINATED. |         |           | DOUBTFUL OR UNKNOWN. |         |           |
|-----------|--------------|---------------|-----------|-------------|---------|-----------|---------------|---------|-----------|----------------------|---------|-----------|
|           | Total Cases. | Total Deaths. | Per Cent. | Cases.      | Deaths. | Per Cent. | Cases.        | Deaths. | Per Cent. | Cases.               | Deaths. | Per Cent. |
| 1885, . . | 32           | 11            | -         | 7           | 0       | -         | 13            | 9       | -         | 12                   | 2       | -         |
| 1886, . . | 2            | 1             | -         | 1           | 1       | -         | -             | -       | -         | 1                    | 0       | -         |
| 1887, . . | 13           | 4             | -         | 6           | 0       | -         | 5             | 2       | -         | 2                    | 2       | -         |
| 1888, . . | 32           | 5             | -         | 15          | 1       | -         | 13            | 3       | -         | 4                    | 1       | -         |
| 1889, . . | 15           | 3             | -         | 11          | 1       | -         | 3             | 1       | -         | 1                    | 1       | -         |
| 1890, . . | 6            | 1             | -         | 2           | -       | -         | 2             | -       | -         | 2                    | 1       | -         |
| 1891, . . | 5            | 1             | -         | 1           | -       | -         | 3             | 1       | -         | 1                    | -       | -         |
| 1892, . . | 19           | 2             | -         | 7           | -       | -         | 10            | 1       | -         | 2                    | 1       | -         |
| 1893, . . | 44           | 6             | -         | 11          | 0       | -         | 27            | 6       | -         | 6                    | 0       | -         |
|           | 168          | 34            | 20.2      | 61          | 3       | 4.9       | 76            | 23      | 30.3      | 31                   | 8       | 25.8      |

*Summary.*—There were in all 168 reported cases in the nine years (1885-93), and 34 deaths, or 20.2 per cent. of the whole.

Of this number 61 were vaccinated, and of these 3 or only 4.9 per cent. died.

The unvaccinated were 76 in number, of whom 23 or 30.3 per cent. died.

There were also 31 in whom the facts as to vaccination were doubtful or not reported, and of this number 8 or 25.8 per cent. died.

By this it appears that the vaccinated had, as compared with the unvaccinated, a six-fold immunity from death by small-pox, which corresponds fairly with other observations upon larger numbers. To this statement it should be added that in very many of the cases recorded as vaccinated, and especially among adults, there had been but one vaccination, and often a single scar only, and that of an imperfect character.

The following table contains the principal items gathered from the reports of cases of small-pox made to the State Board of Health under the provisions of chapter 138 of the Acts of 1883 during the year 1893.

*Record of Cases of Small-pox reported to the State Board of Health during the Year 1893, under the Provisions of Chapter 133 of the Acts of 1893.*

| Number. | Date<br>of<br>Report. | Place<br>of<br>Contracture. | Nationality<br>of<br>Patient. | Occupation.                  | Age.      | Sex. | Previously<br>Vaccinated. | Number of<br>Scars. | Death. |
|---------|-----------------------|-----------------------------|-------------------------------|------------------------------|-----------|------|---------------------------|---------------------|--------|
| 1       | Jan. 1.               | New Bedford.                | Portuguese.                   | Housewife.                   | 25 years. | F.   | No.                       | -                   | -      |
| 2       | Jan. 9.               | New Bedford.                | Portuguese.                   | -                            | 14 mos.   | F.   | No.                       | -                   | -      |
| 3       | Jan. 20.              | Westfield.                  | American.                     | Father and iron-<br>moulder. | 16 years. | M.   | No.                       | -                   | -      |
| 4       | Jan. 20.              | Westfield.                  | American.                     | Wagon maker.                 | 17 "      | M.   | No.                       | -                   | -      |
| 5       | Jan. 20.              | Westfield.                  | American.                     | -                            | 12 "      | M.   | No.                       | -                   | -      |
| 6       | Jan. 20.              | Westfield.                  | American.                     | -                            | 4 mos.    | F.   | No.                       | -                   | 1      |
| 7       | Jan. 20.              | Westfield.                  | American.                     | -                            | 15 years. | M.   | No.                       | -                   | 1      |
| 8       | Feb. 17.              | Barnstable.                 | Ireish.                       | Stone worker.                | 25 years. | M.   | Yes.                      | 2                   | -      |
| 9       | Mar. 4.               | Barnstable.                 | American.                     | Cover maker.                 | 25 "      | F.   | No.                       | -                   | -      |
| 10      | Mar. 26.              | Westfield.                  | German.                       | -                            | 37 yrs.   | M.   | -                         | -                   | -      |
| 11      | April 2.              | Westfield.                  | Fr. Canadian.                 | -                            | Adult.    | F.   | -                         | -                   | -      |
| 12      | April 12.             | North Adams.                | Ireish.                       | Rag sorter.                  | 15 "      | F.   | Yes.                      | -                   | -      |
| 13      | June 1.               | Pepperell.                  | French.                       | Rag sorter.                  | 22 "      | F.   | No.                       | -                   | -      |
| 14      | Sept. 21.             | Holyoke.                    | Italian.                      | Bookbinder.                  | 25 years. | M.   | Yes.                      | 1                   | -      |
| 15      | Oct. 2.               | Holyoke.                    | Italian.                      | -                            | 7 years.  | M.   | No.                       | 1                   | -      |
| 16      | Oct. 4.               | Holyoke.                    | Fr. Canadian.                 | Housewife.                   | 40 years. | F.   | No.                       | -                   | -      |
| 17      | Oct. 26.              | Boston.                     | English.                      | -                            | 11 "      | M.   | Yes.                      | 2                   | -      |
| 18      | Nov. 4.               | Boston.                     | Ireish.                       | Laborer.                     | 17 "      | M.   | No.                       | -                   | -      |
| 19      | Nov. 12.              | Boston.                     | Ireish.                       | -                            | 13 "      | F.   | Yes.                      | 2                   | -      |
| 20      | Nov. 12.              | Boston.                     | Ireish.                       | Housewife.                   | 25 "      | F.   | Yes.                      | 3                   | -      |
| 21      | Nov. 12.              | Boston.                     | American.                     | -                            | 3 "       | F.   | No.                       | -                   | -      |
| 22      | Nov. 13.              | Boston.                     | American.                     | -                            | 19 yrs.   | M.   | No.                       | -                   | -      |
| 23      | Nov. 13.              | Boston.                     | American.                     | -                            | 4 years.  | F.   | No.                       | -                   | -      |
| 24      | Nov. 19.              | Boston.                     | Ireish.                       | Stableman.                   | 28 "      | M.   | Yes.                      | 2                   | -      |
| 25      | Nov. 19.              | Boston.                     | Ireish.                       | Housewife.                   | 30 "      | F.   | Yes.                      | 2                   | -      |
| 26      | Dec. 7.               | Boston.                     | Br. Provinces.                | School boy.                  | 14 "      | M.   | -                         | 0                   | -      |
| 27      | Dec. 7.               | Boston.                     | Br. Provinces.                | Errand boy.                  | 17 "      | M.   | No.                       | -                   | -      |
| 28      | Dec. 7.               | Boston.                     | Br. Provinces.                | Salesman.                    | 22 "      | M.   | No.                       | -                   | -      |
| 29      | Dec. 9.               | Boston.                     | Br. Provinces.                | Table girl.                  | 20 "      | F.   | No.                       | -                   | -      |
| 30      | Dec. 9.               | Boston.                     | Br. Provinces.                | School girl.                 | 10 "      | F.   | No.                       | -                   | -      |
| 31      | Dec. 9.               | Boston.                     | Br. Provinces.                | -                            | 15 "      | F.   | No.                       | -                   | -      |
| 32      | Dec. 9.               | Boston.                     | Br. Provinces.                | -                            | 19 "      | F.   | No.                       | -                   | 1      |
| 33      | Dec. 9.               | Boston.                     | Br. Provinces.                | Carpenter.                   | 34 "      | M.   | Yes.                      | 2                   | -      |
| 34      | Dec. 9.               | Boston.                     | Br. Provinces.                | -                            | 25 "      | F.   | No.                       | -                   | 1      |
| 35      | Dec. 10.              | Boston.                     | Br. Provinces.                | Domestic.                    | 19 "      | F.   | No.                       | -                   | -      |
| 36      | Dec. 12.              | Somerville.                 | Br. Provinces.                | Harness maker.               | 18 "      | M.   | No.                       | -                   | -      |
| 37      | Dec. 13.              | Boston.                     | American.                     | -                            | 1 mo.     | F.   | No.                       | -                   | 1      |
| 38      | Dec. 14.              | Boston.                     | Br. Provinces.                | Domestic.                    | 18 years. | F.   | -                         | -                   | -      |
| 39      | Dec. 15.              | Boston.                     | Br. Provinces.                | Domestic.                    | 20 "      | F.   | -                         | -                   | -      |
| 40      | Dec. 16.              | Boston.                     | Br. Provinces.                | Domestic.                    | 16 "      | F.   | No.                       | -                   | 1      |
| 41      | Dec. 21.              | Boston.                     | Br. Provinces.                | Housewife.                   | 24 "      | F.   | No.                       | -                   | -      |
| 42      | Dec. 23.              | Boston.                     | Br. Provinces.                | Domestic.                    | 19 "      | F.   | No.                       | -                   | -      |
| 43      | Dec. 23.              | Boston.                     | Br. Provinces.                | Shoemaker.                   | 25 "      | M.   | No.                       | -                   | -      |
| 44      | Dec. 26.              | Lowell.                     | -                             | -                            | 22 "      | M.   | -                         | -                   | -      |

NOTES.— 1, 2. Vaccinated about seven months since. 4 and 5. Vaccinated unsuccessfully when a child; no further attempt was made. 9. Vaccinated twenty-four and eighteen years ago, and had varioloid. 9. Contracted from No. 3. 12. Vaccinated six years since. 14. Vaccinated twenty-five years ago; one small scar. 15. Vaccinated ten days before. 17. Imperfect scars. 19. Vaccinated in infancy; contracted small-pox on steamer "Catalonia," from Liverpool. 20. Vaccinated in infancy and nine years ago. Nov. 18, 19 and 20 were contracted from No. 17. 24. Vaccinated in infancy and November 6; contracted from No. 16. 25. Vaccinated in infancy and November 6. 33. Vaccinated in infancy; two imperfect scars. 34. Vaccinated December 9; too late to take effect. 39. Vaccinated December 7.

These forty-four cases present several points which are worthy of note. Most of the cases (43 out of 44) occurred in the cities and large towns. Out of the first sixteen cases which occurred during the year, eleven occurred in places where paper mills using rags exist. There has been no serious epidemic of small-pox in the

State during the past twenty-five years in which cases have not occurred in considerable numbers in such cities and towns, and while only two of the persons in the foregoing list are reported as being employed in handling rags, several of the others are known to have lived in the same families or tenements with persons so employed.

Ten only out of the forty-four are reported as having been of American birth.

Out of the whole number 25 or 56.8 per cent. were females, a circumstance which is quite unusual since the majority of cases are commonly men.

Of the whole number, 8 were under five years of age, 6 were school-children or children of school age, eight to fourteen years, and of these, 3 were unvaccinated.

*Vaccination.*—In consequence of the unusual prevalence of small-pox during the past season it seems proper to state some of the principles relating to vaccination as clearly as possible.

The experience of nearly a century with vaccination has demonstrated its protective power beyond a reasonable doubt. This power, however, is not absolute, nor does it continue throughout adult life. Hence it is desirable that revaccination should be performed at or before the period of puberty.

The provisions of the German law afford a very good rule in this respect. It is therein required that every child shall be vaccinated before the September of the year following its birth, and that every school-child shall be re-vaccinated during its twelfth year.

The result of the enactment of this law in 1874 has been the almost complete extinction of small-pox in Germany since that date. In the six largest cities of the empire the mortality from small-pox was reduced from 92 per 100,000 of the population to 1.4 in the ten years after the enactment of the law.

The opposition to the practice of vaccination is by no means new. It is coeval with the discovery of this extremely valuable means of disease prevention, and the past century has developed nothing new on the part of its opponents, while vaccination itself has received the strongest support in the brilliant researches of Pasteur and others in the direction of protective inoculation for other diseases.

The first secretary of the State Board of Health, Dr. Derby, said of vaccination :—

We may turn the question with ingenious skill, so that its many facets shall reflect a multitude of curious lights, and after all we find that we rest in a security against this most horrid pestilence unknown to former generations.

The operation of vaccination should always be conducted with the greatest care. The following rules (modified from those of the Local Government Board of England) may be observed with advantage :—

1. In the vaccination of infants ascertain that there is not any febrile condition, or irritation of the bowels, or an unhealthy state of the skin; especially any chafing or eczema behind the ears or in the groin, or elsewhere in the folds of the skin. Where there has been recent exposure to the infection of measles or scarlet-fever, and where erysipelas prevails in the place of residence, vaccination should be delayed for a month, or until danger of other infection has passed.

2. In all ordinary cases of primary vaccination, make at least two insertions of lymph not less than a half inch apart. It is desirable that the total area of vesiculation on the same day of the week following the vaccination should amount to not less than a half of a square inch.

3. Direct that care be taken for keeping the vesicles uninjured during their progress, and for avoiding the premature removal of the crusts. Do not use any needless means of "protection" or of "dressing" to a vaccinated arm; but, if in a particular case, you find reason for means of "protection" or of "dressing," define the material and the manner of use of the appliances best adapted to the case, avoiding all such as cannot be readily destroyed and replaced whenever they become soiled.

4. Keep a careful record of vaccinations, in which may be placed the following items: date of vaccination, name, age and sex of child, character and source of lymph used, number of insertions, result of inspection at end of a week, remarks, abnormal appearances, etc.

Record as "successful" only those cases in which a normal vesicle has been produced. In cases of revaccination record as successful only those cases in which either vesicles, normal or modified, or papules surrounded by areolæ, have resulted.

5. Use bovine lymph preferably. In times of epidemics of small-pox, and especially in cases where persons about to be vaccinated have been recently exposed to small-pox, the age of the lymph (time since it was taken from the animal) should be definitely ascertained, and in such cases recent lymph should always be employed in preference to that which is more than ten days old. If bovine lymph cannot be obtained and the lymph from a healthy infant taken on the seventh day after vaccination can be had, this may be used. Humanized lymph should never be taken

from cases of revaccination, but invariably from a primary case and from an infant in good health and of healthy parentage.

6. Keep in good condition the lancets or other instruments employed for vaccination and use them for no other purpose.

When vaccinating, have a clean napkin and a glass of water containing a disinfectant at your side, with which invariably cleanse the lancet after each operation before proceeding to another. Dipping the lancet in strong alcohol and immediately passing it through the flame of a lamp undoubtedly serves to sterilize it.

Never use an ivory point a second time either for the conveyance or for the storage of lymph, but when they have been put to their proper use, break or otherwise destroy them.

“The best results, on the whole, are those which follow the plan of scarification or abrasion.” — *Seaton*.

The greatest care should be taken in performing the operation to secure aseptic conditions, in other words, absolute cleanliness. For this purpose the place of insertion, preferably the outer and anterior part of the arm from three to five inches below the bend of the shoulder, should be washed with soap and water and then wiped dry.

Scarify or lightly abrade the surface in at least two places about an inch apart, until the scarified spots appear slightly red and moist, but not enough to draw blood freely.

Moisten the ivory slips slightly at the points with pure water, and wipe off the lymph upon the scarified places, using at least two points for each person vaccinated.

Never use one point for two persons.

The after treatment: If any blood remains at the points of insertion it should be allowed to dry, and should not be washed off until the third morning after vaccination, when it may be removed by washing gently with a little pure warm water and a clean flannel or linen cloth. After this, a clean piece of soft linen may be sewed around the arm to prevent the sleeve from chafing the vesicles. This should be changed daily.

7. The vaccinator should in all cases require that each vaccinated person should appear at the end of a week for inspection, and especially in each case of primary vaccination, if the operation proves ineffectual, the vaccination should be repeated with fresh lymph.

*Cases of Doubtful Diagnosis.* — In all of the comparatively slight epidemics of small-pox which have occurred in recent years there has been a considerable number of cases in which the diagnosis, especially in the early stage of the disease, was more or less involved in doubt, and this was particularly true of those cases which occurred in the practice of young physicians who have entered upon practice since the epidemic of 1872-73.



Cases of measles, of chicken-pox, as well as some of the ordinary forms of skin diseases, have been mistaken for small-pox, while cases of genuine variola have been reported as chicken-pox, measles, etc. This fact is not to be wondered at when it is known that small-pox has been of such rare occurrence during the twenty years intervening between 1873 and 1893 that probably not one physician in a hundred in the State has met with a single case during that time.

In consequence of this fact it is desirable that any doubtful cases occurring in the practice of physicians who are not familiar with the natural history of the disease should be examined in consultation with a physician who has had experience in such cases. Much doubt and much annoyance to communities where such cases may occur may thus be avoided, and in some instances serious outbreaks may be prevented.

#### *Other Infectious Diseases.*

From such reports as have been received from local boards of health during 1893 it appears that the prevalence of diphtheria and typhoid fever has differed but little in severity from that of the previous year. The number of reported cases and deaths from each of these causes was but little greater for each disease.

From scarlet fever the reported cases and deaths were much larger in number than those of either 1891 or 1892.

From measles the cases and deaths were greater than those of 1891 and very largely in excess of those of 1892.

The statistics giving the number of reported cases and of reported deaths, together with the ratios of fatality, may be found at page 741, under the head of Health of Towns.

Many requests were received during the year for advice in regard to the management and control of infectious diseases, and visits were made to Provincetown, Newburyport, Ludlow, Somerville, Dalton, Hanover, Douglas, Falmouth, Rowley, Topsfield and other places for the purpose of investigating local outbreaks of typhoid fever, scarlet fever and diphtheria, and for affording such assistance to local boards of health as it was in the power of the State Board to give.

*Notification of Infectious Diseases.*

Among the different measures employed by sanitary authorities for the prevention of the spread of infectious diseases, the notification of the occurrence of such diseases now occupies a prominent place. Municipal authorities especially should have the requisite power everywhere to require immediate notice to be given them of every fresh outbreak of diseases dangerous to the public health in order that such authorities may take proper measures for the protection of the community.

The chief advantages of a system of notification lie in the possibility which is thus given to a local board of health to determine the extent of prevalence of an epidemic or a localized outbreak, and to inquire into the local causes which have operated to produce it. The board can then act intelligently in applying the proper remedies for preventing its further spread.

Laws enacted with this object in view have been in force in the older States for many years, but not until within the past ten or twenty years have pains been taken to execute such statutes with such degree of efficiency as to make them really protective. The law requiring the householder to report each case of dangerous disease to the local authority was enacted in Massachusetts in 1792, and that which requires the same duty on the part of the attending physician was enacted in 1827.

There can be no doubt that the law relative to notification has been productive of excellent results in the prevention of disease, especially in the cities and large towns. It has furnished the local boards of health with the necessary information relative to the origin of outbreaks of infectious disease, and in many instances enabled them to take timely steps for preventing its further spread. The law of 1884 requiring local boards to keep records upon this important matter has furnished information as to the prevalence of certain diseases in the principal cities and towns of the State, and has enabled school authorities to guard against the introduction and spread of contagious diseases in the public schools by means of the provision which requires the local board of health to notify the school committee of the occurrence of all cases of such contagious disease. In the smaller towns it is probable that instances of failure to comply with the provisions of the statute are much more frequent than they are in cities.

The statutes referred to in the foregoing comments are as follows:—

[PUBLIC STATUTES, CHAPTER 80, SECTION 78; ACTS OF 1884, CHAPTER 98, AND ACTS OF 1891, CHAPTER 188.]

(1.) When a householder knows that a person within his family is sick of small-pox, diphtheria, scarlet fever or any other disease dangerous to the public health, he shall immediately give notice thereof to the selectmen or board of health of the town in which he dwells, and upon the death, recovery or removal of such person, the rooms occupied and the articles used by him shall be disinfected by such householder in a manner approved by the board of health. Any person neglecting or refusing to comply with either of the above provisions shall forfeit a sum not exceeding one hundred dollars.

(2.) When a physician knows that a person whom he is called to visit is infected with small-pox, diphtheria, scarlet fever or any other disease dangerous to public health, he shall immediately give notice thereof in writing, over his own signature, to the selectmen or board of health of the town; and if he refuses or neglects to give such notice he shall forfeit for each offence not less than fifty nor more than two hundred dollars.

(3.) The boards of health in the several cities and towns shall cause a record to be kept of all reports received in pursuance of the preceding sections, and such record shall contain the names of all persons who are sick, the localities in which they live, the diseases with which they are affected, together with the date and the names of the persons reporting any such cases. The boards of health shall give the school committee immediate information of all cases of contagious diseases reported to them according to the provisions of this act.

(4.) The secretary of the Commonwealth shall furnish the boards of health with blank books for the record of cases of contagious diseases as above provided.

As an additional measure in the same direction the Legislature of 1893 enacted the following law, requiring that contagious diseases reported to the local boards of health shall, in turn, be reported by them to the State Board of Health:—

[CHAPTER 302 OF THE ACTS OF 1893.]

(1.) When the board of health of any city or town has had notice of the occurrence of a case of small-pox or any other disease dangerous to the public health in such city or town, such board of health shall, within twenty-four hours after the receipt of such notice, notify the State Board of Health of the same.

(2.) If the board of health of the city or town, in which a case of small-pox or any other disease dangerous to the public health has occurred,

refuses or neglects to send a notice as required in section one, such city or town shall forfeit its claim upon the Commonwealth for the payment of any expenses which may be incurred as provided in section eighty-three of chapter eighty of the Public Statutes.

This recent law went into effect in June, 1893, but very few returns in compliance with its provisions were received by the State Board of Health until after public notice had been given by the Board by means of a circular which was distributed to every Board of Health throughout the State.

As the "diseases dangerous to the public health" were not specified in the foregoing act, with the exception of small-pox, the Board deemed it desirable for the sake of securing uniform action on the part of local boards, that some definite expression of opinion should be made as to the meaning of the term "other diseases dangerous to the public health."

Hence, in the circular named above, the Board suggested that, in addition to *small-pox*, the following diseases shall be considered as dangerous to the public health within the meaning of the foregoing act: *scarlet fever, measles, typhoid fever, diphtheria, membranous croup, cholera, yellow fever, typhus fever, cerebro-spinal meningitis, hydrophobia, malignant pustule, leprosy and trichinosis.*

A supply of postal blanks was forwarded with the circular for the purpose of enabling local boards of health to comply with the terms of the act.

Various attempts have been made in England to enact a similar statute, but these efforts were unsuccessful until 1889. By the terms of the law then enacted the notification of infectious diseases to the sanitary authority was made compulsory throughout London, while the principle of local option was applied to all other districts.

During the year in which this bill was under consideration by Parliament, intense opposition had been manifested by many of the members of the medical profession throughout England. Objections were offered not only by the people, but also by the medical profession, but the bill passed and finally became a law.

The fallacy of the objections has been abundantly proven by the three years' experience of the towns of England where the Notification Act has been adopted. The notification of each case is made by a certificate furnished by the attending physician, for which a fee of two shillings and sixpence is paid, except in a case where the person

giving the certificate is the medical officer of a public institution, when the fee is one shilling.

The diseases to which this act applies are small-pox, cholera, diphtheria, membranous croup, erysipelas, scarlet-fever, typhus, typhoid and puerperal fevers, and any other infectious disease which may be added to this list by the sanitary authority of a district.

Up to the year 1892, the act had been adopted in 1,051 districts, having an aggregate population of nearly sixteen millions, to which should be added the population of London and fifty towns in which local acts made it compulsory, making in all a population of 24,012,399 over which the act was in force, out of a total of 29,001,018. In a few towns the sanitary authorities had availed themselves of the power to require notification in the case of measles, r  theln, chicken-pox and hydrophobia.

Further information as to the details of the operation of the statute of 1893 may be found upon page 639.

#### OFFENSIVE TRADES.

Under the provisions of the acts relating to noxious and offensive trades the State Board of Health is authorized to hear parties making complaints, and when "in the judgment of the Board the public health or the public comfort and convenience require, the Board may order any person to desist and cease from further carrying on said trades or occupations." No applications under this act were received during the year, but visits and inspections were made at the request of local boards of health in two instances, where rendering works were being conducted.

#### THE BOARD'S EXHIBIT AT THE COLUMBIAN EXPOSITION (1893).

The subject of public hygiene was represented at the Columbian Exposition at Chicago by exhibitions of the work of State and local boards of health. The exhibits of this important department of public work were installed in the Anthropological Building, in the south part of Jackson Park. Of these exhibits none created greater or more favorable comment than that of the State Board of Health of Massachusetts.

It is proper that some account of the exhibition should be made a matter of public record in this report of work for the year 1893.

A communication was received Sept. 24, 1892, from the superintendent of the Bureau of Hygiene and Sanitation of the Department

of Liberal Arts of the Columbian Exposition, calling the attention of the Board to the opportunity that would be given at the Fair for placing before the public the work of State boards of health in the prevention of infectious diseases, and at the same time asking whether the Board desired to be represented at the Exposition.

At a later date (Dec. 28, 1892) further information was received upon the subject, together with a blank form of application for allotment of space in which to install the exhibit of the Board.

At the next meeting of the Board (January, 1893) it was voted to ask for 1,200 square feet of space for the Board's exhibit.

The Board was informed that, in consequence of the fact that only 10,000 feet could be devoted to the whole subject of hygiene and sanitation in the United States, it would be impossible to afford an eighth of it to the State of Massachusetts. It was therefore finally decided to grant the Board 500 feet of space for its purpose. To this space were ultimately added 120 square feet.

An appropriation had already been provided by the Legislature to defray the expenses of such representations as might be made at the Exposition by different departments of the State government, and the sum of \$4,000 was set aside for the exhibit of the State Board of Health. The Board then directed that an exhibit should be prepared representing the progress of public hygiene in the State.

The exhibit consisted of the following items:—

*General Sanitary Work of the Board.*

Complete set of reports of State Board of Health from 1869 to 1891.

Special reports of the Board, circulars upon infectious diseases and other health topics, sets of blank forms and manual of health laws.

Reports of city boards of health of Massachusetts for the year 1892.

*Charts and Diagrams illustrating the Following Subjects.*

The death-rate of Massachusetts for a series of years.

Effect of density of population on the general death rate.

Effect of density of population on the death rate from each of the following diseases (for twenty years, 1871–90): Measles, scarlet fever, diphtheria, small-pox, typhoid fever, cholera infantum, consumption and pneumonia.

Improvement in registration.

Decline in death rates from certain causes.

Seasonal mortality in Massachusetts.

*Geographical Distribution of Eight Diseases.*

Eight maps showing the comparative mortality from measles, scarlet fever, diphtheria, small-pox, typhoid fever, cholera infantum, phthisis and pneumonia.

Diagrams and maps illustrating epidemics of typhoid fever in Springfield and Lowell.

*Engineering Department ( Water Supply and Sewerage ).*

Model of Lawrence Experiment Station, carefully constructed of wood and iron painted, and in a scale of one-half inch to the foot.

Sand sieve.

Steam sterilizer.

Thermostat.

Galvanized-iron filter.

Complete battery of stills.

Sections of sand filters, in glass tubes.

Apparatus for determining the color of waters.

Bacteria stand, with tubes.

Sets of double dishes.

Large map of Massachusetts showing the normal chlorine of different regions.

Small map of Massachusetts showing the normal chlorine of different regions.

Water-shed map of Massachusetts.

Lower basin of Merrimack River (blue print).

Temperature chart.

Chart showing advice to cities and towns, water supplies.

Chart showing advice to cities and towns, sewage disposal.

Chart showing average of water analyses.

Map of North Metropolitan Sewerage System.

Map of Lawrence city filter.

Photographs of Framingham sewage beds.

Pumping station.

Applying sewage. (2 photographs.)

Cornfield treated with sewage.

Photographs of Marlborough sewage beds.

Gate-house.

Underdrains.

Filter-bed.

Filter-beds after harrowing.

Room 86, Massachusetts Institute of Technology (Laboratory of State Board of Health). (2 photographs.)

Lawrence Experiment Station. (3 photographs.)

Photographs of bacteria cultures.

City water of Lawrence and Tank 8.

Tanks 1, 2, 6 and 13.

Forty one-gallon bottles, containing:—

Samples of sewage applied to each of the filters at Lawrence, Framingham, etc.

Samples of effluents from sewage-filters at Lawrence, Framingham, etc.

Samples of sewage containing dyes (with water before and after filtration).

Samples of Merrimack River water before and after filtration.

Samples of surface and ground waters from rivers, ponds, reservoirs, wells, springs, etc. (pure and polluted).

Series of eight-ounce bottles containing samples of filtering materials, sand, gravel, etc.

*Department of Food and Drug Inspection.*

Charts showing ratio of adulteration of milk in Massachusetts.

Charts showing ratio of adulteration of other kinds of food.

Charts showing ratio of adulteration of spices.

Chart showing decrease in ratio of hogs infected with trichinæ under improved modes of feeding.

Chart showing ratio of expenditure for food, clothing, rent, fuel, etc., in different countries.

Micro-photographs of pure articles of food: coffee, pepper, mustard, cloves, ginger, etc.

Micro-photographs of the same when adulterated.

Samples of pure foods, in glass bottles.

Samples of adulterants used in the foregoing, as sold commercially for the purpose of adulteration.

Models of trichinæ, free (male and female) and encysted.

Information was received that the Anthropological Building would be ready for the reception of exhibits by the 12th of April.

The material was collected at the building of the Mechanics' Charitable Association in Boston, and was boxed, ready for shipment, in fifty-four packages, and left Boston on April 10. It arrived at the Fair grounds in good condition on April 12, but the building was then in no condition to receive it, and it was therefore stored near by until the building could be completed. The roof was not put on till April 29.

Prof. W. T. Sedgwick was given charge of installing the exhibit, and went to Chicago for that purpose. He obtained the services of attendants, so that some one was in charge of the exhibit from the outset to the close of the Exposition, a fact which contributed very largely to its success.



In commenting upon this exhibit, Mr. E. C. Hovey, secretary and executive officer of the Massachusetts commission at the Fair, says :—

Two exhibits alone were well-nigh worth the entire sum expended by the Commonwealth on her contributions to these important departments. The exhibits of the Massachusetts State Board of Health and the Rumford Kitchen were *sui generis*, and told to the world in a most striking manner their story of patient investigation and continued research. Through the auspices of the State Board of Health there was installed an exhibit which, in a most complete and graphic manner, laid before the visitor the work which has been accomplished in the State in dealing with the problems of health as dependent upon sanitation. Here also was to be seen a model of the Experiment Station in Lawrence, which it may be truly said has not its equal in the country. The important investigations made by the Board of Health, looking to the prevention of the adulteration of food, were effectively shown, and the walls were covered with charts and statistics which served to demonstrate the nature of the researches made by the Board, researches which have had, and will continue to have, marked influence on the health of the citizens of the Commonwealth.\*

Many thousands of visitors viewed the exhibit of the Board during the continuance of the Fair, and especially during the week of the congress of public hygiene. The Board published a large edition of a guide or prospectus of the exhibit, which was distributed free to all visitors. The exhibit also received very favorable comment in the various medical and sanitary periodicals, not only in the United States but also in foreign countries.

The following notice of award has been received by the Board :—

#### UNITED STATES.

##### DEPARTMENT OF LIBERAL ARTS.

*Exhibitor.* — State Board of Health. *Group 147.* — Class 833.

*Address.* — Boston, Mass. *Exhibit.* — Maps, Charts and Models.

#### AWARD.

For exhaustive examinations and reports upon the public water supplies of the State ; the relation of water supply to the public health, resulting in a definite knowledge as to the ways in which certain diseases are disseminated ; and the best methods of protecting the purity of waters used for

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\* New England Magazine, February, 1894. Article by Commissioner E. C. Hovey.

tuberculous patient should be disinfected and especially the floor and lower parts of the walls. For this purpose washing the floor and all woodwork with a corrosive sublimate solution, one part to one thousand (about one teaspoonful to a gallon of water) should be practised, and the bed and clothing of the last occupant should be submitted to steam disinfection or to boiling water. Strong soapsuds also have efficient disinfecting power, and may be used for washing floors and woodwork. The disinfection should be thoroughly done, but especially so in cases where the habits of the consumptive in regard to disposal of his sputa have been careless.

As a means of spreading information upon this important subject, local boards of health can undoubtedly accomplish much toward the prevention of consumption, by issuing a circular like the following: —

*The Prevention of Consumption.*

Consumption is the most destructive disease of New England, the number of persons dying annually from this cause in Massachusetts amounting to nearly six thousand.

The disease is infectious, and can be communicated from one person to another. The chief danger exists in the expectoration of the sick, and if this expectoration is carefully destroyed little danger need be feared.

Consumptives should be instructed not to spit upon the floors of rooms, public halls, street and railway cars, and other vehicles, nor in the streets, but into pieces of cloth, or receptacles made for the purpose, containing water, or a saturated solution of carbolic acid (one part of carbolic acid crystals to about fifteen parts of water). Such bits of cloth should be destroyed by fire, before the sputa become dry, and other receptacles should be cleansed with scalding water, their contents having been destroyed or otherwise carefully disposed of. Handkerchiefs which may have been used from necessity should be boiled half an hour before washing.

A healthy person should not sleep in the same room with a consumptive.

Remember that sputa must never be allowed to become dry.

OFFICE OF THE STATE BOARD OF HEALTH, BOSTON.  
January, 1896.

LOCAL BOARDS OF HEALTH.

Nearly fifty years ago (1850) the sanitary commission of Massachusetts advised the obligatory appointment of boards of health in every city and town in the State, and after the establishment of the State Board of Health in 1869 this Board frequently called attention to the need of legislation having this end in view. But not until 1877 was legislation enacted requiring such boards to be appointed as a compulsory measure, and even then the requirement applied to cities only. The Board has from time to time urged the necessity of further legislation requiring similar action on the part of towns, and especially in the case of those having large populations.

the Public Statutes (edition of 1882) but also of each of the Blue Books containing the acts and resolves of each successive year since 1882. Copies of the Manual have been furnished to each of the local boards of health throughout the State, to the public health committee of the Legislature, and to other persons interested in public hygiene. The book contains about 200 pages, with a very full index. It has the laws relating to the public health, including those which pertain to the inspection of food and drugs, the registration of vital statistics and the medical examiners' laws.

#### CREMATION.

Under the provisions of chapter 265 of the Acts of 1885 the Legislature authorized the formation of corporations for the purpose of incinerating the bodies of the dead.

By the terms of this act it was provided that —

Every such corporation may acquire by gift, devise or purchase, and hold in fee simple so much real estate not exceeding in value fifty thousand dollars as may be necessary for carrying out the objects connected with and appropriate to the purposes of said corporation, and situated in such place as the state board of health may determine to be suitable for said objects and purposes. No building shall be erected, occupied or used by such corporation until the location and plans thereof, with all details of construction, have been submitted to and approved by said board or some person designated by it to examine them.

Every such corporation may make by-laws and regulations consistent with law and subject to the approval of said state board, for the reception and cremation of bodies of deceased persons, and for the disposition of the ashes remaining therefrom.

Further provision was made in the same act to prevent the concealment of crime in the case of cremated bodies.

Acting under the provisions of this act the Massachusetts Cremation Society applied to the Board April 3, 1893, requesting its approval of a location for a crematory in the city of Boston, the location being a tract of nearly two acres on the north-west side of Walk Hill Street, near the Forest Hills Cemetery.

The Board, after viewing the premises, approved the location. Subsequently, the plans and method of cremation were submitted to the Board, and after examination by a competent engineer these also were approved, together with certain regulations adopted by

topics relative to the work of municipal boards have been presented for discussion. Committees have been appointed to confer with legislative health committees with reference to matters of importance which appear to require further legislation.

The association publishes a quarterly journal in which its transactions appear.

#### OFFENSIVE TRADES.

No complaints were made to the Board during the year under the provisions of the acts relating to offensive trades, and consequently no hearings were held. The board of health of Newburyport requested the advice of the State Board in regard to a rendering establishment in that city, situated at some distance from the populous part of the city. The secretary conferred with the secretary of the local board, and on visiting the establishment in question found it in an extremely filthy condition, both internally and externally, some thirty or forty carcasses of horses in different stages of decomposition lying unburied upon the surface of the ground, while many others, insufficiently buried, had been uncovered by dogs.

Information was received that the premises were subsequently put in good condition and that no further complaints had been made in relation to the same.

#### LOCAL NUISANCES.

A very considerable part of the correspondence received by the Board consists of letters from individuals, or of petitions signed by greater or less numbers of citizens, requesting the State Board to abate local nuisances existing in cities and towns. Often such letters or petitions call the attention of the State Board to the fact that the local board of health has been requested to abate the nuisance but has either refused or neglected to attend to the matter.

So frequent has this class of correspondence become that the State Board has issued a circular which is used as a reply to letters of this character, calling attention to the fact that the State Board has no power or authority to abate an ordinary local nuisance, but that ample power is conferred upon the local board of health to take all proper measures in such cases. If the local board of health refuses or neglects to comply with the request of the petitioners, then the matter may be referred to the county commissioners under the provisions of chapter 80, sections 36, 37 and 38, but not to the State Board of Health.

This statute, however, does not prevent the State Board from consulting with and advising local boards in regard to the disposal of local nuisances whenever such action is necessary.

#### STATISTICAL SUMMARIES OF DISEASE AND MORTALITY.

These summaries comprise the results of the collection of such statistics as are furnished to the Board by the local authorities of cities and towns, either voluntarily or by statute requirements. They consist of four different series or sets of tabular material, as follows:—

1. The weekly mortality returns, or the summary of the voluntary returns of deaths in those cities and towns whose registration officials return these data to the State Board.

2. Summary of cases of infectious diseases reported to local boards of health, selected and compiled from the annual reports of such boards.

3. Summary of cases of infectious diseases reported by local boards to the State Board—chiefly diphtheria, scarlet-fever, measles and typhoid fever—under statutory requirement.

4. Annual returns of deaths in each city and town having over 5,000 population, also by statutory requirement.

As a matter of convenience these summaries have been grouped together, and are presented on pages 711–750 of this report.

#### NOTIFICATION OF INFECTIOUS DISEASES.

The plan of requiring notice to be given of the occurrence of infectious diseases was established nearly a century ago by statutes making such notices compulsory, both on the part of the householder and of the attending physician. But little care was taken to secure the enforcement of such laws until within the past twenty-five years, when these laws were made more efficient by the requirement of penalties for neglect to comply with them and the introduction of other features providing for the systematic recording of data by local boards of health, and still later, by the statute requiring a further report by the local board to the State Board of Health. Similar statutes have been in force in England for several years, and the information thus furnished has frequently proved of great value in tracing the cause of epidemics and of devising and providing means for their prevention.

A summary of the reports received from the different municipal authorities required to report to the State Board of Health may be found in that portion of the report entitled Statistical Summaries of Disease and Mortality.

## REGISTRATION OF VITAL STATISTICS.

In the following summary of the vital statistics of the State for the year 1892, the estimate of population employed as a basis is made upon the same plan as that of the previous year, namely, the geometric rate of increase. Upon this basis the estimate of population for the year 1892 is 2,369,993.

There were 22,507 marriages, 65,824 living births, 2,293 stillbirths and 48,762 deaths registered in Massachusetts in 1892.

The ratios to the estimated living population were as follows : —

|                                       |           |       |                                     |
|---------------------------------------|-----------|-------|-------------------------------------|
| Marriage rate,                        | . . . . . | 9.50  | per 1,000 of the living population. |
| Persons married,                      | . . . . . | 18.99 | " " " " "                           |
| Birth rate,                           | . . . . . | 27.77 | " " " " "                           |
| Death rate,                           | . . . . . | 20.57 | " " " " "                           |
| Excess of birth rate over death rate, | . . . . . | 7.20  | " " " " "                           |

*International Vital Statistics.*

In the following summary are presented the marriage, birth and death rates of the six New England States and those of the principal countries of Europe having registration for a period of twenty years (1871–90) and for the years 1891 and 1892. The first year of registration of Maine completes the list of the New England States for the year 1892.

The six New England States embrace a population of about five millions, and the entire population of the countries embraced in this summary numbers about two hundred and twenty-five millions.

*Summary of the Vital Statistics of the Principal Countries of Europe for Twenty Years, and for 1891 and 1892, together with those of the New England States.*

| STATES AND COUNTRIES.        | TWENTY YEARS — 1871-1890. |             |             |                                       | 1891.          |             |             |                                       | 1892.          |             |             |                                       |
|------------------------------|---------------------------|-------------|-------------|---------------------------------------|----------------|-------------|-------------|---------------------------------------|----------------|-------------|-------------|---------------------------------------|
|                              | Marriage Rate.            | Birth Rate. | Death Rate. | Excess of Birth Rate over Death Rate. | Marriage Rate. | Birth Rate. | Death Rate. | Excess of Birth Rate over Death Rate. | Marriage Rate. | Birth Rate. | Death Rate. | Excess of Birth Rate over Death Rate. |
|                              |                           |             |             |                                       |                |             |             |                                       |                |             |             |                                       |
| Massachusetts, . . . . .     | 18.1                      | 25.7        | 19.7        | 6.0                                   | 18.9           | 27.4        | 19.7        | 7.8                                   | 19.0           | 27.8        | 20.6        | 7.2                                   |
| Maine, . . . . .             | -                         | -           | -           | -                                     | -              | -           | -           | -                                     | 17.1           | 21.2        | 18.4        | 2.8                                   |
| New Hampshire, . . . . .     | 18.6                      | 18.0*       | 18.9        | -                                     | 20.6           | 19.8*       | 19.3        | -                                     | 21.6           | 20.6*       | 21.2        | -                                     |
| Vermont, . . . . .           | 15.6                      | 20.2        | 15.1        | 5.1                                   | 17.0           | 20.0        | 16.9        | 3.1                                   | 17.5           | 19.7        | 18.6        | 1.1                                   |
| Rhode Island, . . . . .      | 18.7                      | 23.7        | 18.0        | 5.7                                   | 18.8           | 25.9        | 18.7        | 7.2                                   | 19.4           | 24.7        | 20.5        | 4.2                                   |
| Connecticut, . . . . .       | 16.0                      | 23.6        | 17.1        | 6.5                                   | 16.8           | 24.8        | 19.2        | 5.6                                   | 16.6           | 24.7        | 19.0        | 5.7                                   |
| England and Wales, . . . . . | 15.6                      | 34.0        | 20.3        | 13.7                                  | 15.6           | 31.4        | 20.2        | 11.2                                  | 15.4           | 30.5        | 19.0        | 11.5                                  |
| Scotland, . . . . .          | 13.9                      | 33.6        | 20.4        | 13.2                                  | 13.9           | 31.2        | 20.7        | 10.5                                  | 14.1           | 30.7        | 18.5        | 12.2                                  |
| Ireland, . . . . .           | 9.0                       | 24.9        | 18.0        | 6.9                                   | 9.2            | 23.1        | 18.4        | 4.7                                   | 9.3            | 22.4        | 19.4        | 3.0                                   |
| Italy, . . . . .             | 15.6                      | 37.3        | 23.6        | 8.7                                   | 15.0           | 37.3        | 26.2        | 11.1                                  | 15.0           | 36.3        | 26.2        | 10.1                                  |
| Denmark, . . . . .           | 15.2                      | 31.7        | 19.0        | 12.7                                  | 13.6           | 31.0        | 20.0        | 11.0                                  | 13.6           | 29.5        | 19.4        | 10.1                                  |
| Norway, . . . . .            | 13.7                      | 30.7        | 16.9        | 13.8                                  | 13.2           | 30.9        | 17.5        | 13.4                                  | 12.6           | 29.6        | 17.7        | 11.9                                  |
| Sweden, . . . . .            | 13.1                      | 29.8        | 17.6        | 12.2                                  | 11.6           | 28.3        | 16.8        | 11.5                                  | -              | -           | -           | -                                     |
| Austria, . . . . .           | 16.3                      | 38.6        | 30.6        | 8.0                                   | 15.4           | 33.1        | 27.9        | 10.2                                  | 15.6           | 36.2        | 28.8        | 7.4                                   |
| Hungary,† . . . . .          | 19.1                      | 44.0        | 33.7        | 10.3                                  | 17.2           | 42.3        | 33.1        | 9.2                                   | -              | -           | -           | -                                     |
| Switzerland, . . . . .       | 14.7                      | 29.4        | 23.1        | 7.3                                   | 14.3           | 28.2        | 20.7        | 7.5                                   | 14.7           | 23.0        | 19.3        | 8.7                                   |
| German Empire,† . . . . .    | 16.4                      | 38.1        | 26.0        | 12.1                                  | 16.1           | 37.0        | 23.4        | 13.6                                  | 15.9           | 35.7        | 24.1        | 11.6                                  |
| Holland, . . . . .           | 15.1                      | 35.2        | 22.6        | 12.6                                  | 14.2           | 33.7        | 20.7        | 13.0                                  | 14.4           | 32.0        | 21.0        | 11.0                                  |
| Belgium, . . . . .           | 14.2                      | 31.0        | 21.4        | 9.6                                   | 14.8           | 29.6        | 21.0        | 8.6                                   | 15.4           | 28.9        | 21.8        | 7.1                                   |
| France, . . . . .            | 15.4                      | 24.5        | 22.8        | 1.8                                   | 15.0           | 22.6        | 22.6        | 0.0                                   | 15.2           | 22.1        | 22.6        | -0.5§                                 |

\* Seven years. Registration of births said to be defective.

† Fifteen years.

‡ Nineteen years.

§ Excess of death rate.

*Marriages.*

The number of marriages (22,507) was greater than that of any previous year. The greatest number occurred in November (2,716) and the least number in March (1,037).

The marriage rate was 18.99, and was higher than that of any year since 1887, when it was 19.0. The estimated marriage rate of the decennial period ending with 1892 was 18.61.

*Births.*

The number of living births registered in Massachusetts during the year 1892 was 65,824, and the birth rate, as calculated upon an estimated population of 2,369,993, was 27.77 per 1,000 of the living population. This was the highest birth rate of any year since 1874, when it was 28.32. The lowest birth rate in the intervening period was that of 1879, which was 22.94. The estimated birth rate of the decennial period ending with 1892 was 26.08.

The ratio of males to females among living births where the sex was stated was 105.6 females to each 100 males.

The greatest number of births occurred in December and the least number in February.

There were 990 illegitimate births registered, or 15 per 1,000 of the living births registered during the year, as compared with 1,078, or 17.1 per 1,000 in 1891.

The births in the thirty cities were 46,597, as compared with 43,828 in 1891, an increase of 6.3 per cent. Those in the remainder of the State were 19,227, as compared with 19,176 in 1891, an increase of less than three-tenths of 1 per cent.

*Deaths.*

The number of deaths (48,762) was greater than that of any previous year. The death rate (20.57 per 1,000) was higher than that of any previous year since 1875. The estimated death rate of the decennial period ending with 1892 was 19.64.

*Infant Mortality.* — The number of deaths of infants under one year old was 10,649, or 21.84 of the total mortality, which was less than that of either 1891 or 1890, and was also greater than the mean of the twenty-year period (1873–92).

The deaths of children under five were 15,225, or 31.22 per cent. of the total mortality, which was less than that of any year for the



past twenty years except that of 1882, which was nearly identical with it.

As compared with the births, the mortality of infants under one was 16.18 per cent. of the living births, which was slightly greater than that of 1891, and also greater than the mean of the twenty-year period (1873-92).

The deaths of centenarians reported in 1892 were thirteen in number, nine of whom were women, and ten were of foreign birth. Of the three women who were of native birth, one died in her native town, and each of the others in a town adjoining her native town.

*Sex.* — The deaths of males were 24,643 and those of females 24,119. But, by the census of 1890, the females were largely in excess of the males, in the ratio of 51.42 per cent. of the former to 48.58 of the latter (nearly). If the same ratio prevailed in 1892, the death rate of males was 21.40 per 1,000, and that of females 19.79, these ratios being in each case higher than those of the census year 1890, and also higher than the mean of the seven census years, 1860, '65, '70, '75, '80, '85, '90.

Stating this more clearly, the deaths of males to 1,000 deaths of females in equal numbers living were 1,059 in 1890, while in 1892, the difference in population of the two sexes being estimated in the same ratio, the deaths of males to 1,000 females in equal numbers living were 1,081. In England, for 1891, the deaths of males to 1,000 deaths of females were 1,128, and for the ten-year period (1881-90) they were 1,123.

### *Causes of Death.*

The number of deaths, the causes of which were not registered in 1892, was 470, or .96 of 1 per cent. of the mortality from all causes. This ratio was smaller than that of any previous year since the beginning of registration, except that of 1891, which was .9 of 1 per cent.

The average of the ten years ending with 1892 was 1.23 per cent. of the total mortality of the period.

The sanitary significance of a table in which is presented the ratio of deaths from specified causes, or groups of causes, to the living population, must be acknowledged, as compared with the older method of comparison with the total mortality. Hence the following table is introduced, in which are presented the deaths from each group of causes, together with the rate per million living for each

group for 1892, and the rate per million for each year of the period (1883-92).

The practical value of international vital statistics becomes more apparent every year. An impetus has been given to such work by the labors of the International Statistical Institute, which convened at Chicago in 1893.

For the sake of comparison the column of means for the ten-year period (1881-90) for England has been added to the following table from the Fifty-fourth Report of the Registrar General of England for 1891.

The deaths from the group of infectious diseases in Massachusetts in 1892 were greater than the mean for the ten-year period (1883-92).

The deaths from the group of constitutional diseases in 1892 were less than those of the ten-year period.

The deaths from the developmental group of causes were slightly less than those of the decade.

The deaths from local diseases have increased from a rate of 7,572 per million in 1884 to 9,651 per million in 1892. The mean ratio for the period was 8,496.

The deaths from violence have not varied very greatly, the extremes being 894 per million in 1883, and 748 in 1884, while the mean was 815.

The deaths from ill-defined and unspecified causes have generally diminished from a maximum of 357 per million in 1883 to a minimum of 176 in 1891, the mean being 242.

The lower line may be read as a general death rate per million, or per thousand of the population, as convenience may dictate, in the latter case the comma being used as a decimal point.

| CAUSES OF DEATH.                        |  | Total Deaths, 1892. | RATE PER MILLION LIVING. |        |        |        |        |        |        |        |        |        | MASSACHUSETTS. |                | ENGLAND. |
|-----------------------------------------|--|---------------------|--------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------------|----------------|----------|
|                                         |  |                     | 1892.                    | 1891.  | 1890.  | 1889.  | 1888.  | 1887.  | 1886.  | 1885.  | 1884.  | 1883.  | Mean, 1883-92. | Mean, 1891-92. |          |
|                                         |  |                     |                          |        |        |        |        |        |        |        |        |        |                |                |          |
| Infectious diseases, . . . . .          |  | 9,248               | 3,903                    | 3,587  | 3,607  | 3,692  | 3,802  | 3,866  | 3,414  | 3,674  | 4,022  | 4,070  | 3,759          | 2,753          |          |
| Constitutional diseases, . . . . .      |  | 9,322               | 3,934                    | 3,923  | 4,110  | 4,136  | 4,334  | 4,429  | 4,464  | 4,564  | 4,548  | 4,604  | 4,296          | 3,825          |          |
| Developmental diseases, . . . . .       |  | 4,770               | 2,013                    | 2,005  | 1,963  | 2,009  | 2,024  | 2,094  | 2,027  | 2,065  | 2,100  | 2,172  | 2,043          | 1,583          |          |
| Local diseases, . . . . .               |  | 22,871              | 9,651                    | 9,117  | 8,714  | 8,352  | 8,702  | 8,382  | 7,738  | 8,277  | 7,572  | 7,921  | 8,406          | 9,785          |          |
| Violence, . . . . .                     |  | 2,081               | 878                      | 804    | 810    | 778    | 787    | 827    | 771    | 748    | 852    | 894    | 815            | 651            |          |
| Ill-defined and not specified causes, . |  | 470                 | 198                      | 176    | 231    | 225    | 253    | 242    | 225    | 257    | 280    | 357    | 242            | 1,042          |          |
| Deaths from all causes, . . . . .       |  | 48,762              | -                        | -      | -      | -      | -      | -      | -      | -      | -      | -      | -              | -              |          |
| Rate per million inhabitants, . . . . . |  | -                   | 20,577                   | 19,612 | 19,435 | 19,192 | 19,902 | 19,840 | 18,639 | 19,615 | 19,374 | 20,108 | 19,651         | 19,149         |          |

Still-births are not embraced in this table.

## STATISTICS OF CERTAIN DISEASES, MASSACHUSETTS, 1873-92.

*Deaths, and Ratios compared with Population and Mortality from All Causes.*

|       | SMALL-POX. |                               |                                | MEASLES. |                               |                                | SCARLET FEVER. |                               |                                | DIPHTHERIA AND CROUP. |                               |                                | TYPHOID FEVER. |                               |                                | CHOLERA INFANTUM. |                               |                                | CONSUMPTION. |                               |                                |
|-------|------------|-------------------------------|--------------------------------|----------|-------------------------------|--------------------------------|----------------|-------------------------------|--------------------------------|-----------------------|-------------------------------|--------------------------------|----------------|-------------------------------|--------------------------------|-------------------|-------------------------------|--------------------------------|--------------|-------------------------------|--------------------------------|
|       | Deaths.    | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.  | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.        | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.               | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.        | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.           | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.      | Death Rate per 10,000 Living. | Percentage of Total Mortality. |
| 1873. | 608        | 4.3                           | 1.97                           | 180      | 1.1                           | .53                            | 1,472          | 9.4                           | 4.34                           | 745                   | 4.7                           | 2.20                           | 1,466          | 8.9                           | 4.15                           | 2,563             | 16.2                          | 7.53                           | 5,556        | 35.3                          | 16.38                          |
| 1874. | 26         | .2                            | .08                            | 161      | 1.0                           | .50                            | 1,382          | 8.6                           | 4.33                           | 913                   | 5.6                           | 2.86                           | 1,147          | 7.1                           | 3.6                            | 2,322             | 14.4                          | 7.28                           | 5,284        | 32.8                          | 16.57                          |
| 1875. | 34         | .2                            | .09                            | 223      | 1.4                           | .67                            | 1,684          | 10.2                          | 4.81                           | 1,880                 | 11.4                          | 5.31                           | 1,039          | 6.4                           | 3.02                           | 2,606             | 15.8                          | 7.45                           | 5,738        | 34.7                          | 16.40                          |
| 1876. | 31         | .2                            | .09                            | 47       | .3                            | .14                            | 1,222          | 7.3                           | 3.68                           | 3,294                 | 19.6                          | 9.92                           | 881            | 5.3                           | 2.85                           | 2,087             | 12.4                          | 6.29                           | 5,927        | 32.2                          | 16.05                          |
| 1877. | 24         | .14                           | .08                            | 135      | .8                            | .44                            | 467            | 2.7                           | 1.49                           | 3,178                 | 18.7                          | 10.14                          | 814            | 4.8                           | 2.69                           | 1,927             | 11.3                          | 6.15                           | 5,457        | 32.0                          | 17.41                          |
| 1878. | 2          | .01                           | .01                            | 305      | 1.8                           | .97                            | 404            | 2.2                           | 1.29                           | 2,317                 | 14.6                          | 8.04                           | 679            | 3.9                           | 2.16                           | 1,573             | 9.1                           | 5.02                           | 5,334        | 30.8                          | 17.04                          |
| 1879. | 7          | .04                           | .02                            | 19       | .1                            | .06                            | 850            | 4.8                           | 2.07                           | 2,293                 | 13.1                          | 7.21                           | 637            | 3.6                           | 2.00                           | 1,349             | 7.7                           | 4.24                           | 5,223        | 29.7                          | 16.42                          |
| 1880. | 38         | .21                           | .11                            | 226      | 1.3                           | .67                            | 574            | 3.2                           | 1.63                           | 2,394                 | 13.4                          | 6.78                           | 882            | 4.9                           | 2.60                           | 2,118             | 11.9                          | 6.00                           | 5,494        | 30.8                          | 15.37                          |
| 1881. | 47         | .25                           | .13                            | 230      | 1.3                           | .63                            | 397            | 2.2                           | 1.09                           | 2,383                 | 13.1                          | 6.54                           | 1,072          | 5.9                           | 2.94                           | 1,861             | 10.3                          | 5.10                           | 5,886        | 32.4                          | 16.14                          |
| 1882. | 45         | .24                           | .12                            | 68       | .4                            | .18                            | 318            | 1.7                           | .86                            | 1,771                 | 9.6                           | 4.81                           | 1,079          | 5.8                           | 2.63                           | 2,159             | 11.7                          | 6.87                           | 5,865        | 31.8                          | 15.93                          |
| 1883. | 5          | .03                           | .01                            | 321      | 1.7                           | .85                            | 575            | 3.1                           | 1.62                           | 1,621                 | 8.6                           | 4.29                           | 860            | 4.6                           | 2.28                           | 1,941             | 10.3                          | 5.14                           | 5,931        | 31.6                          | 15.71                          |
| 1884. | 3          | .01                           | .01                            | 75       | .4                            | .20                            | 627            | 3.3                           | 1.69                           | 1,646                 | 8.6                           | 4.45                           | 875            | 4.6                           | 2.36                           | 2,081             | 10.9                          | 5.62                           | 5,798        | 30.4                          | 15.67                          |
| 1885. | 10         | .10                           | .05                            | 313      | 1.6                           | .82                            | 587            | 3.0                           | 1.84                           | 1,523                 | 7.8                           | 3.98                           | 768            | 3.9                           | 2.02                           | 1,852             | 9.3                           | 4.86                           | 5,955        | 30.7                          | 15.63                          |
| 1886. | -          | -                             | -                              | 130      | .6                            | .35                            | 331            | 1.7                           | .89                            | 1,568                 | 7.8                           | 4.18                           | 800            | 4.0                           | 2.15                           | 1,931             | 9.7                           | 5.18                           | 5,897        | 29.5                          | 15.83                          |
| 1887. | 3          | .01                           | .007                           | 455      | 2.2                           | 1.12                           | 594            | 2.9                           | 1.46                           | 1,628                 | 7.9                           | 3.99                           | 922            | 4.5                           | 2.26                           | 2,131             | 10.4                          | 5.23                           | 5,871        | 28.6                          | 14.40                          |
| 1888. | 8          | .04                           | .02                            | 219      | 1.0                           | .52                            | 504            | 2.4                           | 1.20                           | 1,831                 | 8.7                           | 4.35                           | 945            | 4.5                           | 2.24                           | 2,105             | 10.4                          | 5.21                           | 5,728        | 27.1                          | 13.61                          |
| 1889. | 6          | .03                           | .01                            | 171      | .8                            | .44                            | 185            | .8                            | .44                            | 2,214                 | 10.2                          | 5.30                           | 891            | 4.1                           | 2.13                           | 2,156             | 9.9                           | 5.16                           | 5,981        | 25.7                          | 13.95                          |
| 1890. | 1          | .004                          | .002                           | 114      | .5                            | .26                            | 196            | .9                            | .45                            | 1,626                 | 7.3                           | 3.74                           | 835            | 3.7                           | 1.92                           | 2,491             | 11.1                          | 5.72                           | 5,791        | 25.9                          | 13.31                          |
| 1891. | 1          | .004                          | .002                           | 236      | 1.0                           | .52                            | 246            | 1.1                           | .54                            | 1,218                 | 5.3                           | 2.69                           | 821            | 3.6                           | 1.82                           | 2,771             | 12.0                          | 6.13                           | 5,484        | 23.8                          | 12.14                          |
| 1892. | 2          | .01                           | .004                           | 88       | .4                            | .18                            | 660            | 2.8                           | 1.37                           | 1,455                 | 6.1                           | 2.98                           | 827            | 3.5                           | 1.69                           | 2,898             | 12.2                          | 5.94                           | 5,739        | 24.2                          | 11.77                          |

STATISTICS OF CERTAIN DISEASES, MASSACHUSETTS, 1873-92 — Concluded.  
Deaths, and Ratios compared with Population and Mortality from All Causes — Concluded.

|       | PNEUMONIA. |                               |                                | WHOPING-COUGH. |                               |                                | CANCER. |                               |                                | KIDNEY DISEASES. |                               |                                | HEART DISEASES. |                               |                                | BRAIN DISEASES. |                               |                                |
|-------|------------|-------------------------------|--------------------------------|----------------|-------------------------------|--------------------------------|---------|-------------------------------|--------------------------------|------------------|-------------------------------|--------------------------------|-----------------|-------------------------------|--------------------------------|-----------------|-------------------------------|--------------------------------|
|       | Deaths.    | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.        | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths. | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.          | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.         | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.         | Death Rate per 10,000 Living. | Percentage of Total Mortality. |
| 1873, | 2,007      | 13.3                          | 6.18                           | 264            | 1.7                           | .78                            | 611     | 3.9                           | 1.80                           | 460              | 2.9                           | 1.35                           | 1,256           | 7.9                           | 3.64                           | 2,651           | 16.9                          | 7.82                           |
| 1874, | 2,356      | 14.8                          | 7.49                           | 449            | 2.8                           | 1.41                           | 585     | 3.6                           | 1.83                           | 463              | 2.9                           | 1.45                           | 1,272           | 7.9                           | 3.99                           | 2,545           | 15.8                          | 7.98                           |
| 1875, | 2,940      | 17.8                          | 8.40                           | 242            | 1.5                           | .60                            | 563     | 3.5                           | 1.69                           | 509              | 3.1                           | 1.45                           | 1,331           | 8.1                           | 3.80                           | 2,715           | 16.4                          | 7.76                           |
| 1876, | 2,447      | 14.6                          | 7.37                           | 192            | 1.1                           | .58                            | 657     | 3.9                           | 1.98                           | 488              | 2.9                           | 1.47                           | 1,335           | 8.0                           | 4.02                           | 2,627           | 15.7                          | 7.92                           |
| 1877, | 1,972      | 11.6                          | 6.29                           | 369            | 2.2                           | 1.18                           | 646     | 3.8                           | 2.06                           | 535              | 3.1                           | 1.71                           | 1,355           | 7.9                           | 4.32                           | 2,649           | 13.5                          | 8.44                           |
| 1878, | 2,171      | 12.6                          | 6.93                           | 460            | 2.3                           | 1.28                           | 807     | 4.7                           | 2.58                           | 615              | 3.6                           | 1.96                           | 1,442           | 8.4                           | 4.61                           | 2,900           | 16.8                          | 9.29                           |
| 1879, | 2,647      | 15.0                          | 8.32                           | 392            | 1.7                           | .95                            | 862     | 4.9                           | 2.71                           | 693              | 3.9                           | 2.18                           | 1,515           | 8.6                           | 4.76                           | 2,946           | 16.8                          | 9.20                           |
| 1880, | 3,076      | 17.2                          | 9.71                           | 230            | 1.3                           | .65                            | 928     | 5.2                           | 2.63                           | 698              | 3.9                           | 1.98                           | 1,726           | 9.7                           | 4.89                           | 3,364           | 18.8                          | 9.53                           |
| 1881, | 2,967      | 16.4                          | 8.14                           | 217            | 1.2                           | .59                            | 949     | 5.2                           | 2.60                           | 825              | 4.5                           | 2.27                           | 1,937           | 10.7                          | 5.31                           | 3,355           | 18.5                          | 9.20                           |
| 1882, | 2,932      | 15.9                          | 7.97                           | 265            | 1.4                           | .72                            | 987     | 5.3                           | 2.68                           | 877              | 4.7                           | 2.38                           | 2,025           | 11.0                          | 5.50                           | 3,393           | 18.4                          | 9.22                           |
| 1883, | 3,045      | 16.2                          | 8.07                           | 137            | .7                            | .36                            | 1,026   | 5.5                           | 2.72                           | 959              | 5.1                           | 2.54                           | 2,153           | 11.5                          | 5.70                           | 3,562           | 19.0                          | 9.44                           |
| 1884, | 2,646      | 13.7                          | 7.15                           | 410            | 2.1                           | 1.11                           | 1,090   | 5.6                           | 2.86                           | 1,000            | 5.2                           | 2.70                           | 2,117           | 11.1                          | 5.72                           | 3,609           | 19.2                          | 9.92                           |
| 1885, | 3,408      | 17.9                          | 9.10                           | 184            | .9                            | .48                            | 1,087   | 5.6                           | 2.85                           | 1,088            | 5.6                           | 2.86                           | 2,227           | 11.5                          | 5.85                           | 3,864           | 20.0                          | 10.22                          |
| 1886, | 2,856      | 14.2                          | 7.61                           | 271            | 1.4                           | .73                            | 1,104   | 5.6                           | 2.96                           | 1,135            | 5.7                           | 3.05                           | 2,325           | 11.6                          | 6.24                           | 3,844           | 19.2                          | 10.32                          |
| 1887, | 3,348      | 16.3                          | 8.21                           | 222            | 1.1                           | .57                            | 1,174   | 5.7                           | 2.88                           | 1,120            | 5.4                           | 2.75                           | 2,600           | 13.1                          | 6.60                           | 4,257           | 20.7                          | 10.44                          |
| 1888, | 3,716      | 17.6                          | 8.83                           | 245            | 1.2                           | .58                            | 1,275   | 6.0                           | 3.03                           | 1,318            | 6.2                           | 3.13                           | 3,061           | 14.5                          | 7.27                           | 4,522           | 21.4                          | 10.74                          |
| 1889, | 3,440      | 15.8                          | 8.23                           | 310            | 1.4                           | .74                            | 1,325   | 6.1                           | 3.17                           | 1,298            | 5.8                           | 3.01                           | 3,280           | 14.2                          | 7.85                           | 4,313           | 19.8                          | 10.32                          |
| 1890, | 4,038      | 18.0                          | 9.28                           | 363            | 1.6                           | .83                            | 1,387   | 6.2                           | 3.19                           | 1,273            | 5.7                           | 2.92                           | 3,417           | 15.3                          | 7.85                           | 4,580           | 19.6                          | 10.08                          |
| 1891, | 4,337      | 18.8                          | 9.60                           | 219            | .9                            | .48                            | 1,395   | 6.1                           | 3.09                           | 1,474            | 6.4                           | 3.26                           | 3,592           | 15.6                          | 7.95                           | 4,711           | 20.5                          | 10.42                          |
| 1892, | 5,020      | 21.2                          | 10.29                          | 248            | 1.0                           | .51                            | 1,402   | 6.9                           | 2.87                           | 1,635            | 6.6                           | 3.15                           | 3,783           | 18.7                          | 7.65                           | 5,036           | 21.2                          | 10.33                          |

In the last two tables are presented the numbers of deaths, the death rates per 10,000 of the living population and the percentage of the total mortality for each of the twenty years ending with 1892 and for each of thirteen prominent causes and groups of causes of death.

*Small-pox.* — The number of deaths from small-pox during the year was 2, as compared with 1 in 1891, 1 in 1890, 4 in 1889 and 8 in 1888.

Compared with the estimated living population the death rate from this cause was only .01 of 1 per 10,000 and the percentage of the total mortality was only .004 of 1 per cent. (Further information relative to the prevalence of small-pox will be found under the head of infectious diseases, page viii.)

*Measles.* — The number of deaths from measles in 1892 was 88, as compared with 236 in 1891 and 114 in 1890. The death rate per 10,000 of the estimated population from this cause was .4 and the percentage of the total mortality was .18.

The number of deaths from this cause was less than that of any year since 1884, when it was 75. The minimum death rate from this cause for the twenty-year period was .1 per 10,000 in 1879, and the maximum was 2.2 in 1887.

*Scarlet Fever.* — The number of deaths from scarlet fever in 1892 was 669, as compared with 246 in 1891 and 196 in 1890 and was the greatest number in any year since 1879.

The death rate per 10,000 of the estimated population from this cause was 2.8 and the percentage of the total mortality 1.37.

The minimum death rate from this cause for the twenty-year period (1873-92) was .8 per 10,000 in 1889, and the maximum was 10.2 in 1875.

*Diphtheria and Croup.* — The number of deaths from diphtheria and croup in 1892 was 1,455 as compared with 1,218 in 1891 and 1,626 in 1890.

The death rate per 10,000 of the estimated living population was 6.1 and the percentage of the total mortality was 2.98.

The minimum death rate from these causes for the twenty-year period ending with 1892 was 4.7 per 10,000 in 1873, and the maximum was 19.6 in 1876.

The mean death rate from these causes for the first half of the twenty-year period was much greater than that of the last half.

*Typhoid Fever.* — The number of deaths from this cause in 1892 was 827, as compared with 821 in 1891 and 835 in 1890.

The death rate from this cause per 10,000 of the estimated population was 3.5 and the percentage of the total mortality was 1.69.

The minimum death rate for the twenty-year period ending with 1892 was 3.5 per 10,000 in 1892, and the maximum was 8.9 in 1873.

The mean death rate from this cause for the first half of the twenty-year period was considerably greater than that of the last half.

*Cholera Infantum.* — The number of deaths from cholera infantum in 1892 was 2,898, as compared with 2,771 in 1891 and 2,491 in 1890.

The death rate from this cause per 10,000 of the population was 12.2 and the percentage of the total mortality was 5.94.

The minimum death rate from cholera infantum in the twenty-year period was 7.7 per 10,000 of the estimated population in 1879, and the maximum was 16.2 in 1873, the first year of the period. In the previous year (1872) however, the death rate from this cause was higher than that of any year of registration either before or since that date.

*Consumption.* — The number of deaths from this disease in 1892 was 5,739, as compared with 5,484 in 1891 and 5,791 in 1890.

The death rate per 10,000 of the estimated population from this cause was 24.2 and the percentage of the total mortality 11.77.

The minimum death rate from this cause for the twenty-year period ending with 1892 was 23.8 per 10,000 in 1891, and the maximum was 35.3 in 1873, the first year of the period.

In comparing the two ten-year periods 1873–82 and 1883–92, there is found to be a very marked decrease in the mean death rate of the latter as compared with that of the former.

*Pneumonia.* — The deaths from pneumonia were 5,020, as compared with 4,337 in 1891 and 4,038 in 1890.

The death rate from this cause per 10,000 of the estimated population was 21.2 and the percentage of the total mortality 10.29.

The minimum death rate from pneumonia for the twenty-year period (1873–92) was 11.6 per 10,000 in 1877 and the maximum was 21.2. The increase in the death rate from pneumonia during the twenty-year period was greater than the decrease in the death rate from consumption.

*Whooping-cough.* — The deaths from whooping-cough in 1892 were 248, as compared with 219 in 1891 and 363 in 1890.

The death rate per 10,000 of the estimated population from this cause was 1 and the percentage of the total mortality was .51 of 1 per cent.

The minimum death rate of the twenty-year period ending with 1892 was .7 per 10,000 in 1883 and the maximum was 2.8 in 1874.

*Cancer.* — The deaths from cancer in 1892 were 1,402, as compared with 1,395 in 1891 and 1,387 in 1890.

The death rate from this cause per 10,000 of the living population was 5.9 in 1892 and the percentage of the total mortality was 2.87.

The minimum death rate from this cause for the twenty-year period was 3.5 per 10,000 in 1875, and the maximum was 6.2 in 1890.

There was a comparatively steady increase in the death rate from cancer from 1877 to 1890 and then a slight decrease in the last three years of the period.

*Kidney Diseases.* — The number of deaths from kidney diseases in 1892 was 1,535, as compared with 1,474 in 1891 and 1,273 in 1890.

The death rate per 10,000 of the estimated population from this group of causes in 1892 was 6.5 and the percentage of the total mortality was 3.15.

There was an increase with considerable regularity in the mortality from this cause during the twenty-year period, from a minimum of 2.9 per 10,000 of the population in 1873 to the maximum of 6.5 per 10,000 in 1892. This excessive increase is, however, more apparent than real, and may be interpreted as mainly due to more intelligent methods of diagnosis.

*Heart Diseases.* — The number of deaths from heart diseases registered in 1892 was 3,733, as compared with 3,592 in 1891 and 3,417 in 1890.

The death rate per 10,000 of the estimated population from this group of causes was 15.7 and the percentage of the total mortality was 7.65.

There has been a tolerably uniform increase in the death rate from this group of causes during the twenty-year period, the minimum death rate being 7.9 per 10,000 in 1873, '74 and '77 and the maximum 15.7 in 1892.



*Brain Diseases.* — This group includes the deaths attributed to apoplexy, paralysis, insanity, the indefinite term “cephalitis,” softening of the brain and other unspecified diseases of the brain, the whole number of deaths from this group in 1892 being 5,036 as compared with 4,711 in 1891 and 4,389 in 1890.

The death rate per 10,000 of the estimated population from these causes in 1892 was 21.2 and the percentage of the total mortality was 10.33.

The minimum death rate from this cause for the twenty-year period was 13.5 in 1877, and the maximum was 21.4 in 1888. The mean death rate from these causes in the last half of the period was considerably greater than that of the first half. For the last eight years of the period the death rate from these causes was nearly stationary.

The deaths from local diseases in Massachusetts have not differed very greatly in their relative incidence upon the population, from those of England, as is shown in the following quotation from the Registrar General's Fifty-fourth Annual Report for 1891.

“*Local Diseases.* — The most noticeable feature presented by the diseases included in this class was the great increase of mortality from diseases of the Circulatory and Respiratory Systems. The rates respectively were 1,826 and 4,474 per million living, and in each case the highest on record. The explanation is doubtless to be found in the prevalence of epidemic influenza. The deaths from nervous diseases, however, showed no such increase. They were in the proportion of 1,748 to a million living; and this rate differed but little from those of the three next preceding years. The mortality from diseases of the Urinary System was 467 per million living, this being the highest rate yet recorded, and marking a further step in the almost continuous increase shown for a long series of years under this heading.”

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From certain infectious causes not mentioned in the foregoing enumeration there were the following numbers of deaths in 1892; those of 1891 are also presented, for the purpose of comparison: —

|                              | NUMBER OF DEATHS. |       |                            | NUMBER OF DEATHS. |       |
|------------------------------|-------------------|-------|----------------------------|-------------------|-------|
|                              | 1891.             | 1892. |                            | 1891.             | 1892. |
| Cerebro-spinal meningitis, . | 154               | 86    | Diarrhœa, . . . .          | 639               | 584   |
| Erysipelas, . . . .          | 210               | 234   | Malarial fevers, . . . .   | 62                | 81    |
| Puerperal fever, . . . .     | 56                | 81    | Hydrophobia, . . . .       | 9                 | 1     |
| Influenza, . . . .           | 546               | 967   | Glanders, . . . .          | 1                 | 0     |
| Dysentery, . . . .           | 234               | 193   | Malignant pustule, . . . . | 1                 | 5     |

*Malarial Fevers.* — There were in all 81 deaths registered in 1892 from ague and remittent fevers. These occurred as follows: —

|                           |    |                           |    |
|---------------------------|----|---------------------------|----|
| Worcester County, . . . . | 16 | Berkshire County, . . . . | 3  |
| Hampden " . . . .         | 15 | Dukes " . . . .           | 1  |
| Middlesex " . . . .       | 10 | Franklin " . . . .        | 1  |
| Suffolk " . . . .         | 9  | Plymouth " . . . .        | 1  |
| Bristol " . . . .         | 8  | Barnstable " . . . .      | 0  |
| Essex " . . . .           | 6  | Nantucket " . . . .       | 0  |
| Hampshire " . . . .       | 6  |                           |    |
| Norfolk, " . . . .        | 5  | Total, . . . .            | 81 |

The number of registered deaths from the same causes in 1891 was 62, and in 1890 60, and the total number for the ten years ending with 1892 was 584.

*Influenza.* — For the purpose of comparison the statistics relating to influenza which were published in the last report (p. xxxiv.) and also in the Forty-ninth Registration Report, 1890, are here reproduced together with those of 1892.

The deaths from certain diseases of the respiratory organs and from heart diseases are also given in the same table.

*Mortality from All Causes, and from Influenza, Pneumonia, Phthisis, Bronchitis and Heart Diseases, by Months, for 1889, 1890, 1891 and 1892.*

## 1889.

| Cause.            | January. | February. | March. | April. | May.  | June. | July. | August. | September. | October. | November. | December. | Totals. |
|-------------------|----------|-----------|--------|--------|-------|-------|-------|---------|------------|----------|-----------|-----------|---------|
| Influenza, .      | 2        | 2         | 3      | 3      | 1     | 1     | 1     | -       | -          | 2        | -         | 12        | 27      |
| Pneumonia, .      | 394      | 359       | 463    | 436    | 328   | 163   | 117   | 114     | 119        | 232      | 291       | 423       | 3,440   |
| Phthisis, .       | 492      | 431       | 482    | 507    | 463   | 406   | 426   | 470     | 463        | 453      | 415       | 513       | 5,581   |
| Bronchitis, .     | 109      | 135       | 173    | 147    | 92    | 62    | 62    | 70      | 84         | 111      | 109       | 122       | 1,276   |
| Heart diseases, . | 278      | 233       | 273    | 279    | 289   | 235   | 266   | 245     | 210        | 271      | 237       | 299       | 3,115   |
| Total, .          | 1,275    | 1,159     | 1,394  | 1,372  | 1,173 | 929   | 872   | 899     | 876        | 1,060    | 1,052     | 1,360     | 13,430  |
| All causes, .     | 3,237    | 3,064     | 3,516  | 3,573  | 3,353 | 3,121 | 4,224 | 4,213   | 3,650      | 3,368    | 2,984     | 3,474     | 41,777  |

## 1890.

|                   |       |       |       |       |       |       |       |       |       |       |       |       |        |
|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| Influenza, .      | 246   | 65    | 32    | 21    | 9     | 8     | 5     | 1     | 4     | 5     | 6     | 9     | 411    |
| Pneumonia, .      | 1,072 | 397   | 396   | 452   | 55    | 191   | 138   | 108   | 113   | 210   | 265   | 411   | 4,038  |
| Phthisis, .       | 733   | 477   | 530   | 512   | 488   | 451   | 446   | 437   | 436   | 418   | 424   | 439   | 5,791  |
| Bronchitis, .     | 298   | 136   | 195   | 168   | 129   | 86    | 63    | 53    | 72    | 89    | 106   | 138   | 1,533  |
| Heart diseases, . | 406   | 273   | 291   | 283   | 282   | 226   | 242   | 235   | 280   | 298   | 265   | 336   | 3,417  |
| Total, .          | 2,755 | 1,348 | 1,444 | 1,436 | 1,193 | 962   | 894   | 834   | 905   | 1,020 | 1,066 | 1,333 | 15,190 |
| All causes, .     | 5,300 | 3,273 | 3,583 | 3,437 | 3,249 | 2,840 | 3,962 | 4,545 | 3,615 | 3,223 | 3,021 | 3,480 | 43,528 |

## 1891.

|                   |       |       |       |       |       |       |       |       |       |       |       |       |        |
|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| Influenza, .      | 9     | 9     | 23    | 89    | 107   | 36    | 12    | 9     | 9     | 5     | 6     | 232   | 546    |
| Pneumonia, .      | 474   | 377   | 473   | 577   | 549   | 233   | 136   | 93    | 92    | 177   | 318   | 838   | 4,337  |
| Phthisis, .       | 459   | 405   | 500   | 510   | 504   | 427   | 436   | 422   | 423   | 463   | 405   | 530   | 5,484  |
| Bronchitis, .     | 154   | 158   | 166   | 157   | 170   | 121   | 86    | 58    | 73    | 113   | 133   | 269   | 1,658  |
| Heart diseases, . | 366   | 272   | 315   | 307   | 319   | 244   | 250   | 279   | 255   | 307   | 300   | 378   | 3,592  |
| Total, .          | 1,462 | 1,221 | 1,477 | 1,640 | 1,649 | 1,061 | 920   | 861   | 882   | 1,065 | 1,162 | 2,247 | 15,617 |
| All causes, .     | 3,578 | 3,133 | 3,714 | 3,802 | 3,795 | 3,126 | 4,070 | 4,455 | 3,765 | 3,714 | 3,318 | 4,715 | 45,185 |

## 1892.

|                   |       |       |       |       |       |       |       |       |       |       |       |       |        |
|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| Influenza, .      | 573   | 180   | 71    | 43    | 26    | 17    | 12    | 4     | 5     | 9     | 16    | 11    | 967    |
| Pneumonia, .      | 1,450 | 595   | 544   | 505   | 400   | 196   | 128   | 100   | 161   | 200   | 294   | 447   | 5,020  |
| Phthisis, .       | 587   | 447   | 539   | 515   | 546   | 424   | 455   | 455   | 404   | 462   | 441   | 464   | 5,739  |
| Bronchitis, .     | 478   | 246   | 226   | 145   | 135   | 82    | 50    | 56    | 74    | 126   | 144   | 124   | 1,886  |
| Heart diseases, . | 483   | 327   | 373   | 343   | 310   | 267   | 237   | 285   | 258   | 254   | 314   | 282   | 3,733  |
| Total, .          | 3,571 | 1,795 | 1,753 | 1,551 | 1,417 | 986   | 882   | 900   | 902   | 1,051 | 1,209 | 1,328 | 17,345 |
| All causes, .     | 6,309 | 3,896 | 4,161 | 3,990 | 3,786 | 3,197 | 4,565 | 4,717 | 3,664 | 3,484 | 3,357 | 3,636 | 48,762 |

An examination of these tables shows quite plainly the sharp rise in the mortality from influenza with a coincident rise in the mortality from pneumonia, phthisis, bronchitis and heart diseases in the winter of 1889-90, culminating in January; another epidemic of less magnitude in the spring of 1891, culminating in April and May, and the still greater epidemic of the winter of 1891 and '92 culminating in January, 1892.

These, together with other minor causes, increased the mortality of January 1892 to 6,309 deaths which was greater by 2,246 than the mean monthly mortality of the year, and greater by more than 1,000 than the mortality of any month in the ten-year period (1883-1892).

*Hydrophobia.*—The mortality from this cause which had attained to considerable numbers in 1889 and 1890, again fell to a single death in 1892.

During the six years ending with 1887 there had been no reported deaths from this cause. There were then 2 deaths from hydrophobia in 1888, 14 in 1889, 17 in 1890, 9 in 1891 and 1 in 1892.

The whole number of deaths from this cause for the period of registration ending with 1892 (fifty-one years and eight months) was 116, of which number 96 or 82.8 per cent. were males and 20 were females.

### *Mortality of Cities.*

The rapid growth of the urban population in Massachusetts as contrasted with that of the smaller towns is a sufficient reason for publishing in a separate table the number of deaths from all causes together with those from the principal infectious diseases in each city in the State.

By this table it appears that the total number of deaths in the cities in 1892 was 32,202 as compared with 30,049 in 1891, and those in the towns were 16,560 as compared with 15,136 in 1891.

The population of the 30 cities including Medford and Everett, by the census of 1890 was 1,394,444 or 62.3 per cent. and that of the towns was 844,499 or 37.7 per cent. of the total population, while a half century earlier, the census showed that the cities (or places having more than 10,000 in each) constituted less than one-fourth of the population.

*Deaths 1891 and 1892, Mean Death-rate of Five Census Years, and Deaths from Certain Infectious Diseases, 1892, in the Urban Population of Massachusetts.*

| Number.                | Total Deaths, 1891. | Total Deaths, 1892. | Mean Death Rate, Five Census Years (1870-90). | Small-pox. | Measles. | Scarlet Fever. | Diphtheria and Group. | Typhoid Fever. | Cholera Infantum. | Consumption. | Pneumonia. | Whooping-cough. |
|------------------------|---------------------|---------------------|-----------------------------------------------|------------|----------|----------------|-----------------------|----------------|-------------------|--------------|------------|-----------------|
| 1 Boston.              | 10,526              | 11,921              | 24.1                                          | -          | 34       | 261            | 483                   | 137            | 563               | 1,552        | 1,144      | 67              |
| 2 Worcester.           | 1,801               | 1,817               | 19.7                                          | -          | 1        | 15             | 60                    | 17             | 127               | 207          | 158        | 11              |
| 3 Lowell.              | 1,075               | 2,229               | 22.5                                          | -          | 11       | 13             | 23                    | 77             | 238               | 251          | 215        | 7               |
| 4 Fall River.          | 1,914               | 1,960               | 23.4                                          | -          | 27       | 27             | 59                    | 27             | 228               | 163          | 175        | 27              |
| 5 Cambridge.           | 1,449               | 1,523               | 19.9                                          | -          | 2        | 10             | 53                    | 15             | 92                | 216          | 132        | 9               |
| 6 Lynn.                | 999                 | 1,040               | 17.8                                          | -          | 2        | 3              | 30                    | 13             | 74                | 134          | 136        | 5               |
| 7 Lawrence.            | 1,120               | 1,216               | 22.5                                          | -          | 1        | 6              | 28                    | 50             | 130               | 95           | 156        | 7               |
| 8 Springfield.         | 886                 | 995                 | 19.3                                          | -          | 3        | 14             | 48                    | 39             | 63                | 116          | 76         | 7               |
| 9 New Bedford.         | 984                 | 991                 | 20.9                                          | 2          | -        | 13             | 10                    | 15             | 72                | 125          | 84         | 8               |
| 10 Somerville.         | 782                 | 718                 | 14.2                                          | -          | -        | 13             | 8                     | 14             | 38                | 90           | 68         | 4               |
| 11 Holyoke.            | 713                 | 922                 | 23.1                                          | -          | 8        | 13             | 71                    | 16             | 72                | 88           | 102        | 11              |
| 12 Salem.              | 606                 | 717                 | 22.1                                          | -          | -        | 3              | 11                    | 18             | 46                | 77           | 78         | -               |
| 13 Chelsea.            | 678                 | 650                 | 16.7                                          | -          | -        | 13             | 18                    | 10             | 34                | 83           | 71         | 3               |
| 14 Haverhill.          | 556                 | 495                 | 17.8                                          | -          | -        | 5              | 2                     | 13             | 26                | 80           | 44         | 2               |
| 15 Brockton.           | 410                 | 416                 | 16.2                                          | -          | 1        | 2              | 15                    | 8              | 16                | 40           | 62         | 1               |
| 16 Taunton.            | 445                 | 595                 | 19.5                                          | -          | 1        | 8              | 12                    | 9              | 30                | 61           | 67         | 7               |
| 17 Gloucester.         | 419                 | 431                 | 21.8                                          | -          | -        | 4              | 2                     | 3              | 10                | 50           | 48         | -               |
| 18 Newton.             | 349                 | 393                 | 19.1                                          | -          | 1        | 7              | 8                     | 4              | 17                | 49           | 46         | -               |
| 19 Malden.             | 390                 | 462                 | 17.0                                          | -          | -        | 2              | 13                    | 6              | 23                | 52           | 29         | 2               |
| 20 Fitchburg.          | 400                 | 445                 | 17.0                                          | -          | -        | 2              | 6                     | 5              | 40                | 43           | 54         | 3               |
| 21 Waltham.            | 360                 | 319                 | 15.3                                          | -          | -        | 10             | -                     | 5              | 7                 | 59           | 46         | -               |
| 22 Pittsfield.         | 315                 | 322                 | 18.3                                          | -          | 1        | 10             | 12                    | 6              | 9                 | 37           | 61         | 1               |
| 23 Quincy.             | 292                 | 284                 | 18.7                                          | -          | 1        | 2              | 10                    | 7              | 11                | 51           | 17         | -               |
| 24 Northampton.        | 268                 | 297                 | 17.2                                          | -          | 1        | 6              | 9                     | 3              | 20                | 27           | 28         | 1               |
| 25 Chicopee.           | 321                 | 395                 | 20.5                                          | -          | 1        | 7              | 6                     | 24             | 36                | 41           | 39         | 4               |
| 26 Newburyport.        | 304                 | 310                 | 21.1                                          | -          | -        | 4              | 23                    | 3              | 14                | 42           | 23         | 2               |
| 27 Marlborough.        | 241                 | 247                 | 17.2                                          | -          | -        | 3              | 3                     | 8              | 17                | 30           | 30         | 7               |
| 28 Woburn.             | 263                 | 270                 | 18.3                                          | -          | -        | 4              | 8                     | 8              | 12                | 35           | 25         | 1               |
| 29 Medford.            | 149                 | 207                 | -                                             | -          | -        | 3              | 3                     | 2              | 15                | 18           | 14         | -               |
| 30 Everett.            | 227                 | 255                 | -                                             | -          | -        | 3              | 10                    | 1              | 19                | 50           | 28         | 4               |
| The 30 cities.         | 30,049              | 32,292              | 21.4                                          | 2          | 73       | 510            | 1,059                 | 553            | 2,006             | 3,928        | 3,236      | 201             |
| The rest of the State. | 15,136              | 16,560              | 17.5                                          | 0          | 15       | 150            | 396                   | 274            | 802               | 1,811        | 1,784      | 47              |
| The whole State.       | 45,185              | 48,762              | 19.7                                          | 2          | 88       | 660            | 1,455                 | 827            | 1,294             | 5,739        | 5,020      | 248             |

The growth of the cities included in the foregoing table was approximately at the rate of  $3\frac{7}{10}$  per cent. per year for the period 1885 to 1890. While that of the remainder of the State was at the rate of only  $1\frac{6}{100}$  per cent. (geometric rate).

Estimating the growth in 1892 at the same rates for these two classes of the population, the mortality rates from the principal diseases included in the foregoing table are presented in the following table. In the two lower lines the mortality rates are reduced to a standard of 1,000 in the urban population for the convenience of comparison, and may be read as follows:—

For every 1,000 deaths from all causes in the urban population, there were 879 deaths in the remainder of the State in equal numbers living. For every 1,000 deaths from consumption in the urban population, there were 794 deaths in the remainder of the State in equal numbers living.

*Death Rates from Certain Diseases in 1892, per 10,000 of the Estimated Living Population, and the same Reduced to a Standard of 1,000 in the Urban or Dense Population.*

|                                  | All Causes,<br>Per 1,000. | Measles. | Scarlet<br>Fever. | Diphtheria<br>and Croup. | Typhoid<br>Fever. | Cholera<br>Infantum. | Phtisis. | Pneumonia. | Whooping-<br>cough. |
|----------------------------------|---------------------------|----------|-------------------|--------------------------|-------------------|----------------------|----------|------------|---------------------|
| <i>Per 10,000 of Population.</i> |                           |          |                   |                          |                   |                      |          |            |                     |
| Urban population, . . .          | 21.5                      | .49      | 3.46              | 7.1                      | 3.7               | 13.9                 | 26.2     | 21.6       | 1.34                |
| Remainder of the State, . .      | 18.9                      | .17      | 1.7               | 4.5                      | 3.1               | 9.2                  | 20.8     | 20.4       | .54                 |
| Urban population, . . .          | 1,000                     | 1,000    | 1,000             | 1,000                    | 1,000             | 1,000                | 1,000    | 1,000      | 1,000               |
| Remainder of the State, . .      | 879                       | 347      | 491               | 634                      | 838               | 662                  | 794      | 944        | 403                 |

### *The Significance of General or Crude Death Rates.*

The crude death rate obtained by estimating the ratio of the number of deaths to the living population has been employed for many years as an index of the sanitary condition of a community, and for comparing its sanitary condition with that of other communities. While this method may be trusted in the comparison of the death rates of a nation, a State, county, city or town at different periods of time (since the age and sex distribution of communities remain fairly constant when comparisons are made for brief periods or successive years), it cannot be trusted for the comparison of

different towns, cities, States and countries with each other, when the age and sex distribution differs widely as for example, in our own State, in the case of Barnstable and Bristol counties, or Barnstable and Suffolk.

In support of this statement Dr. Farr says "Independently of other causes of variation, the mortality of different populations will differ according as they consist of numbers in various proportions at the ages at which the mortality is high or low."

"It is not too much to say that death rates calculated on the gross population are practically worthless as evidence of the sanitary conditions of communities less than entire nations." Dr. E. F. Willoughby, *Hand-book of Public Health and Demography*.

For the purpose of facilitating the methods of correcting death rates according to age and sex distribution, Dr. Ogle of the British Registrar General's office and J. Körösi, Director of Statistics of Hungary, have proposed the employment of standards of population in which a normal or standard distribution of ages and sexes is presented. For this purpose Dr. Ogle combines the populations of seven principal European countries including about 170 million inhabitants and presents a table in which the average distribution of these populations is given by sexes and age periods, the whole number of such periods being twelve. For the purpose of comparison with other countries, States, cities or smaller communities, this method has the disadvantage of requiring an amount of computation which becomes burdensome, and secondly, the age periods employed above 20 years do not correspond with those which have usually been adopted in Massachusetts and other American communities, and while there are some advantages in adopting a distribution into the periods 25-35, 35-45, etc., instead of 20-30, 30-40, etc., the differences are so slight as not to make it advisable to change the existing methods.

Körösi of Buda-Pesth suggests a method which is less cumbrous than the foregoing. He does not deem it essential for this purpose to adopt a sex distribution, but employs a distribution of ages only and divides them into four periods as follows:—

- All ages under one year.
- One to twenty years.
- Twenty to fifty years.
- All over fifty years.

For the purpose of comparison he suggests the use of a standard representing a healthy population having a constantly low death rate as is the case with Sweden.

The foregoing age periods were adopted by M. Körösi after trials with different periods. They differ somewhat from those which have been in use, but he states that it "was found to be preferable to group the first year separately, and that there was no sensible change produced by placing the next nineteen years in one single group."

### *The Returns of Medical Examiners.*

The whole number of returns of medical examiners for the year 1892, under the provisions of the inquest laws, was 2,210.

Of this number, 72 or 3.26 per cent. were deaths by homicide, 274 or 12.40 per cent. were suicides, 974 or 44.07 per cent. were deaths from accident or negligence, and 890 or 40.27 per cent. were the result of causes not due to violence, but to different natural causes and alcoholism. More than one-half of this group were from heart diseases and diseases of the nervous system usually of a sudden character.

*Sex.* — Out of the whole number of deaths returned by the medical examiners 1,642 or 74.3 were those of males, 560 or 25.3 were of females, and the sex of 8 was not stated.

The following summary presents the data of these cases by sexes for the period of eight years (1885–92).

| YEARS.            | SEX.   |               |          |               |              |               | Totals. |
|-------------------|--------|---------------|----------|---------------|--------------|---------------|---------|
|                   | Males. | Percent-ages. | Females. | Percent-ages. | Unspecified. | Percent-ages. |         |
| 1885, . . . . .   | 973    | 76.1          | 286      | 22.4          | 19           | 1.5           | 1,278   |
| 1886, . . . . .   | 1,027  | 74.5          | 319      | 23.2          | 32           | 2.3           | 1,378   |
| 1887, . . . . .   | 1,191  | 76.5          | 350      | 22.5          | 15           | 1.0           | 1,556   |
| 1888, . . . . .   | 1,261  | 76.4          | 373      | 22.6          | 17           | 1.0           | 1,651   |
| 1889, . . . . .   | 1,253  | 75.8          | 388      | 23.4          | 13           | 0.8           | 1,654   |
| 1890, . . . . .   | 1,303  | 73.5          | 449      | 25.3          | 21           | 1.2           | 1,773   |
| 1891, . . . . .   | 1,362  | 74.0          | 457      | 24.8          | 21           | 1.2           | 1,840   |
| 1892, . . . . .   | 1,642  | 74.3          | 560      | 25.3          | 8            | 0.4           | 2,210   |
| Totals, . . . . . | 10,012 | -             | 3,182    | -             | 146          | -             | 13,340  |
| Means, . . . . .  | -      | 75.0          | -        | 23.8          | -            | 1.2           | -       |



The first bars upon the stream above North Billerica begin about eighteen hundred feet from the dam, where there is a narrow rocky channel extending for a distance of five hundred feet up-stream. About four hundred feet above its upper end and about half a mile from the dam is the Fordway bar, which extends for a distance of seven hundred feet up-stream. About six hundred feet above the Fordway bar is Pollard's bar, which is about half as long as the Fordway bar and at a considerably lower level. The total fall over these bars in the morning when the water was flowing over the flashboards at the dam was found to be only about three inches, and any improvement which could be made at these bars with the sum which would be available would have been sufficient to lower the water only a very small amount at this place unless there was also a lowering of the dam.

In the course of the investigations it was learned that during the summer season the quantity of water which can be utilized in daytime at the dam is limited by the obstruction caused by the Fordway bar and the narrow rocky channel below it. Owing to these obstructions the mills cannot use in the daytime the full flow of the river during the twenty-four hours, for a portion of it runs to waste over the flashboards at night. If these obstructions should be partially or wholly removed, the mills could use a greater proportion of the total flow of the river and the water power would be benefited thereby. There was some question, therefore, whether in view of this benefit the mill owners might not be willing to lower their flashboards by an amount dependent upon the improvement of the channels, and in case such an arrangement had been made the river above the Fordway bar would have received the full benefit of the lowering of the flashboards and a slight additional lowering due to the greater capacity of the channel through the bar; but the bars in the vicinity were found to be composed of hard material which would have been expensive to move and would have limited the improvement in the rest of the river to such a degree that a satisfactory and permanent improvement of the channel above could not have been made with the amount of money available; and in view of all the circumstances the conclusion was reached that the money could best be spent in dredging the bars in the river farther up.

Several plans were considered, one of which provided for cutting a channel thirty feet wide on the bottom through the bars in Concord below the Assabet River, and twenty feet wide on the bottom through the bars above the Assabet, as far as the bar just above Farm bridge. The bottoms of these channels were to be five feet below the water level after the improvement had been completed; but it was not proposed to make any channel through a few bars where the depth was about four feet, as the depth of water over these bars was so great that they did not obstruct the flow of the water in more than a slight degree. A depth of five feet was decided upon to prevent the future obstruction of the channel by weeds.

## WATER SUPPLY AND SEWERAGE.

The general law giving to the State Board of Health supervision of inland waters, and imposing certain duties upon the Board in relation to water supplies and systems of sewerage and sewage disposal has been so frequently quoted in the recent reports of the Board that it is not essential to quote the statute again in full.

Acting under the Statutes of 1888 the work of the Board in this direction has been conducted during the past year in the same manner as in previous years. This work now constitutes a very important branch of the operations of the Board.

The report of this department of the Board for 1893 comprises the following topics:—

The advice of the Board to the authorities of cities, towns and corporations and individuals upon proposed or existing systems of water supply and sewage disposal under the provisions of section 3 of chapter 375 of the Acts of 1888.

A continuation of the examination of water supplies, comprising the results of chemical and microscopical examinations of public water supplies. The examination of the waters of the following rivers, the Blackstone, Charles, Merrimack, Nashua, Neponset, Housatonic and Taunton were continued and other examinations were made of the Charles, Deerfield, Shawsheen and Ware and the Nashua and its tributaries in connection with the investigations for a Metropolitan water supply.

In the summary of water supply statistics it appears that 146 cities and towns, having a total population of 1,949,455, were provided with water supplies, the majority of these places having in each a population of over 4,000. There were also 206 towns which were not provided with public water supplies only one of which had a population of more than 4,500.

The total population of places not supplied was 289,488 or but little more the one-eighth of the population of the State.

The paper by Professor Drown upon "the Amount of and Character of Organic Matter in Soils and its Bearing on the Storage of Water in Reservoirs," has a practical bearing upon all water supplies where artificial storage basins are constructed by impounding water in valleys and meadows having a surface either partially or wholly of loam or peat.

Mr. Geo. W. Fuller, biologist in charge of the Lawrence Experiment Station, details the work performed at the station during the sixth year of its existence. The principal topics treated of in his report are the character of the sewage used for experiment, the average purification attained, the permanency of filters, their management, experiments upon rapid filtration of sewage from which the sludge has been removed, sub-surface application of sewage, experiments with sand clogged by sewage, effect of polarite in removing color of dye-stuffs in sewage, removal of bacteria, work of the sewage filters in 1893, filtration of water, effects of rate of filtration, depth of material, size of sand grains, scraping, disturbing upper layer of filter, removal of layer of loam, freezing surface layers, rapidly filling from below, amount of loss of head and method of application of water upon its bacterial purification. A detailed account is given of the work of the water filters during 1893 together with the chemical and bacterial analyses of the water supplied and of the effluent water of the Lawrence city filter for the first seven months of its operation.

Hiram F. Mills, C.E., member of the Board, presents a description of the "Filter of the Water Supply of the City of Lawrence and its Results," and shows in this paper, —

1. "The insufficiency of the self-purification of streams.
2. The ready conveyance of typhoid fever down a stream by sewage-polluted drinking water.
3. The practicability of protecting a community against an infected drinking water supply by natural sand filtration."

The paper entitled "Sewage Purification of Cities and Towns in Massachusetts" presents a brief description together with chemical analyses of sewage and effluents from the systems in use in the following places: Amherst, Norfolk county jail, Framingham, Gardner, Lenox, Marlborough, Medfield, Wellesley College and Westborough.

Mr. Allen Hazen, the chemist in charge at the Experiment Station at Lawrence in 1890-93, was appointed as chemist of the department of water supply, sewerage and fire protection at the World's Columbian Exposition at Chicago, and presents in this volume a description of the process there employed for disposal of the sewage of the Exposition by precipitation and the results attained by this process.

## METROPOLITAN WATER SUPPLY.

Within the period of the past forty years or more and since the beginning of the general introduction of a public water supply into Boston the growth of the city has been rapid, and this growth has extended outward, until the suburban municipalities have acquired a population nearly as large as that of the city, the whole district within ten miles of and including Boston containing nearly a million inhabitants.

Public water supplies have now been introduced into each of the twenty-eight cities and towns embraced within this limit. The rapid growth of the towns has not only been attended with an increase in the absolute consumption of water in the district, but the relative or *per capita* consumption has also been considerably increased. To supply this demand very much of the available territory suitable for use as sources for yielding water has been taken by the cities and towns within this district. In some instances the density of the population living upon the area of the different water-sheds has increased to such an extent as to become a serious menace to the health of the population consuming the water, in consequence of the increased pollution which usually follows a corresponding increase of population.

In the words of the present report (p. 6) "The experience of the past year (1893) has emphasized the urgent need of a new water supply for this district, as not only has the water supply of Boston and the district supplied from Mystic Lake been nearly exhausted, as above indicated, but the water supplies of a majority of the places in the Metropolitan district have been in a similar condition."

The urgent demands of the authorities of these municipalities for larger and purer supplies of water finally resulted in legislative action, and the following law was enacted by the Legislature of 1893, entrusting to the State Board of Health the duty of making a general investigation of the subject of a water supply for this Metropolitan district.

## [ACTS OF 1893, CHAPTER 459.]

AN ACT RELATIVE TO PROCURING A WATER SUPPLY FOR THE CITY OF BOSTON  
AND ITS SUBURBS.

*Be it enacted, etc., as follows:*

SECTION 1. The state board of health is hereby authorized and directed to investigate, consider and report upon the question of a water supply for

the city of Boston and its suburbs within a radius of ten miles from the state house, and for such other cities and towns as in its opinion should be included in connection therewith.

SECT. 2. The said board shall forthwith proceed to investigate and consider this subject, including all questions relating to the quantity of water to be obtained from available sources, its quality, the best methods of protecting the purity of the water, the construction, operation and maintenance of works for storing, conveying or purifying the water, the cost of the same, the damages to property, and all other matters pertaining to the subject.

SECT. 3. The said board shall have power to employ such engineering and other assistance and to incur such expenses as may be necessary for carrying out the provisions of this act.

SECT. 4. The said board shall report fully with plans and estimates to the legislature on or before the first Wednesday in January in the year eighteen hundred and ninety-five, and shall append to its report drafts of bills intended to accomplish the recommendations of the board.

SECT. 5. The total amount of money which shall be expended out of the treasury of the Commonwealth in carrying out the provisions of this act shall not exceed forty thousand dollars. The Commonwealth shall be reimbursed for the amount expended by the cities and towns which are to receive the benefit of the system recommended in the report, in proportion to the population of each.

SECT. 6. Before incurring any expense the board shall from time to time estimate the amounts required and shall submit the same to the governor and council for their approval, and no expense shall be incurred beyond the amount so estimated and approved.

SECT. 7. This act shall take effect upon its passage. [*Approved June 9, 1893.*]

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Immediately after the passage of this Act, the Board entered upon the work of investigation, and began the necessary surveys to ascertain the best supply for the district. This work has been carried on without interruption since June, 1893.

While it is too early to publish conclusions relative to a definite source of water supply for the district, it may be said that the investigations made up to the present time indicate that an abundant supply of good water for the Metropolitan District may be obtained without excessive expenditure.

## IMPROVEMENT OF THE CHARLES RIVER.

By the provisions of Chapter 475 of the Acts of 1893, the Board of Metropolitan Park Commissioners and the State Board of Health were constituted a joint board to investigate "the sanitary condition and prepare plans for the improvement of the beds, shores and waters of the Charles River, between Charles River bridge and the Waltham line on Charles River, and for the removal of any nuisances therefrom."

The joint board, thus constituted, was authorized to employ engineers and experts and to incur necessary expenses not exceeding \$5,000.

This act recognizes the existence of conditions in the specified portion of the river which have for a long time constituted a general nuisance, offensive to the sight and smell, in consequence of the serious pollution of the river and of the daily exposure of large areas of mud flats upon which the polluting matter in the river is deposited.

To remedy this foul and unsightly condition the Board has given its attention, and after surveying the territory and areas included in the provisions of the act and investigating the sanitary condition of the contiguous population, made its report to the Legislature in May, 1894 (House Doc. 775, 1894), the time for the presentation of the report having been extended by Chapter 57 of the Resolves of 1894.

The plan proposed involves the construction of a dam and a lock at the lower portion of the estuary above Craigie's bridge, by means of which the water above the dam will be kept at a constant level. While this dam may be regarded as the principal feature of the plan, other features are worthy of note, especially the treatment of the shores of the proposed basin.

One great improvement in this region is already nearly completed, the Metropolitan Sewerage System, which, when in operation, will remove a great amount of pollution from the river.

The report of the Landscape Architects to the joint board closes as follows: — "Charles River, freed from sewage, from defiling industries, from mud flats and from mud banks, and dedicated with its borders to the use and enjoyment of the public as a drainage channel, an open space, a parkway, a chain of playgrounds and a boating course, will perform its highest possible service to the Metropolitan com-

munity, and will return to the community profits, both tangible and intangible, which will annually increase."

#### INFECTIOUS DISEASE HOSPITALS.

The subject of providing separate accommodations for hospitals for persons suffering with infectious diseases of a dangerous character has become quite prominent during the past two or three years in Massachusetts cities, and is likely to become still more a subject of paramount importance in future years.

The fact that 400 such establishments exist in England alone, and the number there is constantly increasing, is sufficient to show the estimate in which they are held in Great Britain.

In response to a demand for information upon this subject, a paper has been prepared by the Secretary for the present report, containing the most recent information upon the subject, together with a brief compilation embodying the practice of other countries in this direction.

#### SUMMARY OF WEEKLY MORTALITY REPORTS.

Under this title may be found a summary of the returns sent to the office of the State Board at the close of each week from the principal cities and towns, of the deaths which have been reported to the local Boards of Health. These returns embrace a statement of the total number of deaths, the number of deaths of children under 5 years of age, and the number from each one of the principal infectious diseases.

This system of voluntary returns keeps the State Board informed of the progress of epidemics, their outbreak and their decline, and serves as a valuable index of the health of the population, its chief advantage consisting in its frequency and the fact that the Board receives its information direct from the local authorities.

#### HEALTH OF TOWNS.

In the portion of the report devoted to the health of towns may be found a digest of the principal facts of importance gathered from the city and town reports of Boards of Health of the year 1893.

This summary also contains a table in which are stated the number of cases of the principal infectious diseases which are reported to the local Boards of Health. In addition to the cases reported another parallel column contains the registered deaths from the same causes in these cities and towns and the ratio of fatality in the State at large.

## ROUTINE WORK OF THE BOARD.

The Board, in the performance of its duties under the provisions of the Statutes, has held at least one meeting in each month during the year, with such meetings of its standing committees as were essential to the proper performance of its work. The work of the year is presented in detail under the different topics referring to the prescribed duties of the Board.

Advice has been given almost daily at the office to local Boards of Health and to individuals seeking advice upon sanitary questions, and in instances, where occasion required, visits have been made by the secretary and by the engineers of the Board to cities and towns for the purpose of making investigation and inspecting and giving advice.

One public hearing only was held during the year (on April 10, 1893) and that had reference to the taking of land for the sewage disposal of Brockton under the provisions of chapter 124 of the Acts of 1890.

The statistics of mortality have been compiled and published each week at the office of the Board in the form of a weekly bulletin, which also contains once a month a report of the work done in the line of food and drug inspection, together with the prosecutions made under the Food and Drug Acts. In addition to the foregoing, during the past year the statistics of reports of cases of infectious diseases returned under the provisions of chapter 302 of the Acts of 1893, have been introduced in these bulletins.

The following table presents certain statistical data relative to the routine work of the Board :—

## STATISTICAL TABLE FOR THE YEAR ENDING SEPT. 30, 1893.

|                                                                                            |            |
|--------------------------------------------------------------------------------------------|------------|
| Whole number of samples of foods and drugs examined during the year,                       | 6,409      |
| Samples of milk examined (included in the foregoing), . . . .                              | 3,073      |
| Whole number examined since beginning of work in 1883, . . . .                             | 53,573     |
| Whole number of samples of milk examined since beginning of work in 1883, . . . . .        | 27,076     |
| Number of warning notices issued relative to adulteration during the year,                 | 423        |
| Number of prosecutions against offenders during the year, . . . .                          | 96         |
| Number of convictions during the year, . . . . .                                           | 92         |
| Amount of fines secured during the year, . . . . .                                         | \$2,476.00 |
| Force employed at Boston, for food and drug inspection, chemists and assistants, . . . . . | 2          |
| At Amherst, . . . . .                                                                      | 1          |
| Inspectors, . . . . .                                                                      | 3          |
| Total, . . . . .                                                                           | 6          |



TABLE 1. — *Marriages, Births and Deaths in Massachusetts (1842-1894), with Population and Rates per 1,000 Living.*

| YEARS.              | Population. | Marriages. | Births. | Deaths. | Excess of Births over Deaths. | Persons Married to 1,000. | Births to 1,000 Persons. | Deaths to 1,000 Persons. | Excess Rate of Births over Deaths. |
|---------------------|-------------|------------|---------|---------|-------------------------------|---------------------------|--------------------------|--------------------------|------------------------------------|
| *1841-42, . . . . . | 783,116     | 5,742      | 8,571   | 9,544   | -                             | -                         | -                        | -                        | -                                  |
| *1842-43, . . . . . | 806,862     | 5,807      | 8,750   | 10,684  | -                             | -                         | -                        | -                        | -                                  |
| *1843-44, . . . . . | 831,328     | 4,304      | 14,757  | 8,338   | -                             | -                         | -                        | -                        | -                                  |
| *1844-45, . . . . . | 856,536     | 4,863      | 15,711  | 8,844   | -                             | -                         | -                        | -                        | -                                  |
| *1845-46, . . . . . | 882,508     | 5,263      | 16,486  | 12,114  | -                             | -                         | -                        | -                        | -                                  |
| *1846-47, . . . . . | 909,267     | 5,390      | 17,097  | 14,492  | -                             | -                         | -                        | -                        | -                                  |
| *1847-48, . . . . . | 936,838     | 5,287      | 16,515  | 15,009  | -                             | -                         | -                        | 17.17                    | -                                  |
| †1848, . . . . .    | -           | 4,015      | 12,540  | 12,475  | -                             | -                         | -                        | 19.58                    | 5.16                               |
| †1849, . . . . .    | 965,245     | 6,936      | 25,773  | 20,423  | 5,350                         | -                         | 26.70                    | 21.16                    | 5.54                               |
| 1850, . . . . .     | 994,514     | 10,345     | 27,664  | 16,906  | 11,058                        | 20.80                     | 27.82                    | 16.70                    | 11.12                              |
| 1851, . . . . .     | 1,020,673   | 11,966     | 28,661  | 18,984  | 9,727                         | 23.44                     | 28.08                    | 18.55                    | 9.53                               |
| 1852, . . . . .     | 1,047,620   | 11,578     | 29,802  | 18,482  | 11,320                        | 22.10                     | 28.45                    | 17.64                    | 10.81                              |
| 1853, . . . . .     | 1,075,072   | 12,828     | 30,920  | 20,301  | 10,619                        | 23.86                     | 28.76                    | 18.88                    | 9.88                               |
| 1854, . . . . .     | 1,103,350   | 13,683     | 31,997  | 21,414  | 10,583                        | 24.80                     | 29.00                    | 19.41                    | 5.59                               |
| 1855, . . . . .     | 1,132,389   | 12,329     | 32,845  | 20,798  | 12,047                        | 21.77                     | 29.01                    | 18.37                    | 10.64                              |
| 1856, . . . . .     | 1,151,461   | 12,265     | 34,445  | 20,734  | 13,711                        | 21.30                     | 29.91                    | 18.00                    | 11.91                              |
| 1857, . . . . .     | 1,170,864   | 11,789     | 35,320  | 21,280  | 14,040                        | 20.05                     | 30.16                    | 18.17                    | 11.99                              |
| 1858, . . . . .     | 1,190,584   | 10,527     | 34,491  | 20,776  | 13,715                        | 17.68                     | 28.97                    | 17.45                    | 11.52                              |
| 1859, . . . . .     | 1,210,657   | 11,475     | 35,442  | 29,976  | 14,466                        | 18.95                     | 29.28                    | 17.33                    | 11.95                              |
| 1860, . . . . .     | 1,231,067   | 12,404     | 36,051  | 23,068  | 12,983                        | 20.15                     | 29.28                    | 18.74                    | 10.54                              |
| 1861, . . . . .     | 1,238,177   | 10,972     | 35,445  | 24,085  | 11,360                        | 17.72                     | 28.63                    | 19.45                    | 9.17                               |
| 1862, . . . . .     | 1,245,328   | 11,014     | 32,275  | 22,974  | 9,301                         | 17.69                     | 25.92                    | 18.45                    | 7.47                               |
| 1863, . . . . .     | 1,252,521   | 10,873     | 30,314  | 27,751  | 2,563                         | 17.36                     | 24.20                    | 22.15                    | 2.05                               |
| 1864, . . . . .     | 1,259,756   | 12,513     | 30,449  | 28,763  | 1,686                         | 19.87                     | 24.17                    | 22.83                    | 1.35                               |
| 1865, . . . . .     | 1,267,031   | 13,051     | 30,249  | 26,152  | 4,097                         | 20.60                     | 23.87                    | 20.64                    | 3.23                               |
| 1866, . . . . .     | 1,302,992   | 14,428     | 34,085  | 23,637  | 10,448                        | 22.14                     | 26.16                    | 18.14                    | 8.02                               |
| 1867, . . . . .     | 1,339,976   | 14,451     | 35,062  | 22,773  | 12,289                        | 21.57                     | 26.17                    | 17.00                    | 9.17                               |
| 1868, . . . . .     | 1,378,010   | 13,856     | 36,193  | 25,603  | 10,590                        | 20.12                     | 26.26                    | 18.58                    | 7.68                               |
| 1869, . . . . .     | 1,417,125   | 14,826     | 36,141  | 26,054  | 10,087                        | 20.92                     | 25.50                    | 18.39                    | 7.12                               |
| 1870, . . . . .     | 1,457,351   | 14,721     | 38,259  | 27,329  | 10,930                        | 20.20                     | 26.25                    | 18.75                    | 7.50                               |
| 1871, . . . . .     | 1,494,334   | 15,746     | 39,791  | 27,943  | 11,848                        | 21.08                     | 26.63                    | 18.70                    | 7.93                               |
| 1872, . . . . .     | 1,532,258   | 16,142     | 43,235  | 35,019  | 8,216                         | 21.08                     | 28.22                    | 22.85                    | 5.37                               |
| 1873, . . . . .     | 1,571,146   | 16,437     | 44,481  | 33,912  | 10,569                        | 20.92                     | 28.31                    | 21.58                    | 6.73                               |
| 1874, . . . . .     | 1,611,022   | 15,564     | 45,631  | 31,887  | 13,744                        | 19.32                     | 28.32                    | 19.79                    | 8.53                               |
| 1875, . . . . .     | 1,651,912   | 13,663     | 43,996  | 34,978  | 9,018                         | 16.54                     | 26.63                    | 21.17                    | 5.46                               |
| 1876, . . . . .     | 1,677,351   | 12,749     | 42,149  | 33,186  | 8,963                         | 16.20                     | 25.13                    | 19.78                    | 5.34                               |
| 1877, . . . . .     | 1,703,182   | 12,758     | 41,850  | 31,342  | 10,508                        | 14.98                     | 24.67                    | 18.40                    | 6.17                               |
| 1878, . . . . .     | 1,729,410   | 12,893     | 41,238  | 31,303  | 9,935                         | 14.91                     | 23.84                    | 18.10                    | 5.74                               |
| 1879, . . . . .     | 1,756,042   | 13,802     | 40,295  | 31,801  | 8,494                         | 15.72                     | 22.94                    | 18.11                    | 4.83                               |
| 1880, . . . . .     | 1,783,085   | 15,538     | 44,217  | 35,292  | 8,925                         | 17.42                     | 24.80                    | 19.79                    | 5.01                               |
| 1881, . . . . .     | 1,813,818   | 16,768     | 45,220  | 36,458  | 8,762                         | 18.49                     | 24.93                    | 20.10                    | 4.83                               |
| 1882, . . . . .     | 1,845,081   | 17,684     | 45,070  | 36,785  | 8,885                         | 19.17                     | 24.75                    | 19.93                    | 4.82                               |
| 1883, . . . . .     | 1,876,883   | 18,194     | 47,285  | 37,748  | 9,537                         | 19.38                     | 25.19                    | 20.11                    | 5.08                               |
| 1884, . . . . .     | 1,909,233   | 17,333     | 48,615  | 36,990  | 11,625                        | 18.16                     | 25.46                    | 19.33                    | 6.08                               |
| 1885, . . . . .     | 1,942,141   | 17,052     | 48,790  | 38,094  | 10,696                        | 17.56                     | 25.12                    | 19.61                    | 5.51                               |
| 1886, . . . . .     | 1,998,174   | 18,018     | 50,788  | 37,244  | 13,544                        | 18.04                     | 25.41                    | 18.64                    | 6.77                               |
| 1887, . . . . .     | 2,055,823   | 19,533     | 53,174  | 40,763  | 12,411                        | 19.00                     | 25.87                    | 19.85                    | 6.04                               |
| 1888, . . . . .     | 2,115,136   | 19,739     | 54,893  | 42,097  | 12,796                        | 18.66                     | 25.95                    | 19.90                    | 6.05                               |
| 1889, . . . . .     | 2,176,159   | 20,397     | 57,075  | 41,777  | 15,298                        | 18.74                     | 26.23                    | 19.20                    | 7.03                               |
| 1890, . . . . .     | 2,238,943   | 20,838     | 57,777  | 43,528  | 14,249                        | 18.62                     | 25.81                    | 19.44                    | 6.37                               |
| 1891, . . . . .     | 2,288,911   | 21,675     | 63,004  | 45,185  | 17,819                        | 18.94                     | 27.53                    | 19.74                    | 7.79                               |
| 1892, . . . . .     | 2,339,993   | 22,507     | 65,824  | 48,762  | 17,062                        | 19.24                     | 28.13                    | 20.84                    | 7.29                               |
| 1893, . . . . .     | 2,392,216   | 22,814     | 67,192  | 49,084  | 18,108                        | 19.07                     | 28.09                    | 20.52                    | 7.57                               |
| 1894, . . . . .     | 2,445,604   | 20,619     | 66,936  | 46,791  | 20,145                        | 16.86                     | 27.37                    | 19.14                    | 8.24                               |
| 1895, . . . . .     | 2,500,183   | -          | -       | -       | -                             | -                         | -                        | -                        | -                                  |

\* The statistics of the first eight years of registration are for the years ending with April 30 of each year.

† The second line of statistics for 1848 is for the eight months ending Dec. 31, 1848.

‡ The statistics for 1849 and for each of the following years are for the calendar years ending Dec. 31.

The number of applications received since July, 1886, when the act relating to water supply and sewerage first went into operation, is as follows :—

|                  |           |
|------------------|-----------|
| 1886, . . . . .  | 8         |
| 1887, . . . . .  | 22        |
| 1888, . . . . .  | 28        |
| 1889, . . . . .  | 38        |
| 1890, . . . . .  | 23        |
| 1891, . . . . .  | 53        |
| 1892, . . . . .  | 56        |
| 1893, . . . . .  | 51        |
| Total, . . . . . | <hr/> 279 |

### RECOMMENDATIONS.

The following recommendations were made to the Legislature at the beginning of the session of 1894 :—

1. With reference to the continuance of the work of the Board under the provisions of chapter 375 of the Acts of 1888 the Board recommends the continuance of the investigations already commenced and those indicated as desirable in the report upon Water Supply and Sewerage (Senate Doc. 4, 1894).

For these purposes, and to make the necessary investigations in order to advise cities, towns, corporations and individuals in regard to the best method of assuring the purity of intended or existing water supplies, and the best method of disposing of sewage, and to carry out the other provisions of chapter 375 of the Acts of 1888, the Board estimates that the sum of \$27,000 will be required.

### 2. *As to Notification of Contagious Diseases.*

That the laws in reference to the notification of contagious diseases to certain State authorities be so amended that the law now in force in regard to small-pox shall be extended to include other diseases dangerous to the public health.

### 3. *State Vaccine Institution.*

In its Twentieth Annual Report, 1888, the State Board of Health introduced the subject of establishing in the State one or more places at which vaccine lymph could be furnished under the supervision of the State, so that regular supplies of lymph could be furnished to all State institutions, to the local authorities of cities and towns, and to such physicians as might choose to obtain their lymph from such an institution.

This plan is adopted at present in nearly all foreign countries where vaccination is practised, and with the most successful result. The plan of public vaccinal institutes has reached its highest development in Germany, where at least thirty such establishments, well equipped and under thorough administration, furnish lymph for vaccination to all who desire it. By this plan the purity of the lymph can be satisfactorily assured, and the physician or local board of health can procure it direct from the institution, thus avoiding the delay of ordering through agents and middlemen.

As a result of this plan as well as of their very thorough enforcement of the laws, Germany is to-day more free from the scourge of small-pox than any other country in the world.

The Board therefore recommends that an appropriation of \_\_\_\_\_ be made for the purpose of carrying out this plan, under the supervision of such authority as the Legislature may direct.

#### *4. As to Vital Statistics.*

That, inasmuch as an intimate study and knowledge of the vital statistics of a community are the basis of wise sanitary administration, the data gathered annually by the Secretary of the Commonwealth, in accordance with the provisions of existing statutes, be submitted in their entirety to the Board of Health for such consideration and report as may seem to promote most fully the public welfare. Such a course would place this State in harmony with the usage in nearly all the states of this Union having registration, and in the civilized countries of Europe.

#### *5. As to Medical Inspectors of Health.*

The following bill was recommended :—

**PROVIDING FOR THE APPOINTMENT OF ADVISORY MEDICAL INSPECTORS OF HEALTH THROUGHOUT THE COMMONWEALTH.**

*Be it enacted, etc., as follows :*

**SECTION 1.** The governor, by and with the advice and consent of the council, shall, as soon as may be after the passage of this act, divide the Commonwealth into such number of districts, to be known as health districts, as he may deem proper and necessary for carrying out the purposes of this act.

**SECT. 2.** After the division provided in the foregoing section the governor shall nominate, and by and with the advice and consent of the council, shall appoint in each health district one able and discreet person, learned in the science of medicine, to be advisory medical inspector of health in said district. Every such nomination shall be made at least seven days prior to the appointment.

**SECT. 3.** Said advisory medical inspectors of health shall hold their offices for a period of seven years from the time of their respective appoint-

ments, and shall be liable to removal from office by the governor and council at any time for cause shown.

SECT. 4. Each advisory medical inspector of health shall reside in the district to which he is appointed, and his removal therefrom shall be equivalent to a resignation of his office. His powers and duties shall be advisory only. He shall inform himself respecting all influences affecting or threatening to affect injuriously the public health within the district, and shall promptly notify the local authorities of the existence of all conditions affecting or likely to affect the health of the district, and shall advise with said authorities as to the best methods of controlling the same.

SECT. 5. Each advisory medical inspector of health shall keep a record of his proceedings and observations, and shall annually make a report to the health authorities of each city or town within his district touching matters affecting said city or town, and shall transmit a copy of each report to the State Board of Health on or before the thirty-first day of October in each year.

SECT. 6. Each advisory medical inspector of health shall from time to time as requested furnish to the State Board of Health information touching the sanitary condition of the whole or any part of his district. He may make such reports and suggestions to the State Board of Health or to the local authorities as he may deem advisable; but shall in every instance forward to the State board a copy of any such communication with the local authorities.

SECT. 7. The governor, by and with the advice of the council, shall establish from time to time the salaries of said advisory medical inspectors of health, having reference in each district to the extent of territory, the number of inhabitants, the character of the business there carried on, and the amount of time likely to be required for the proper discharge of the duties. The salary thus established shall be paid from the treasury of the Commonwealth quarterly.

SECT. 8. This act shall take effect upon its passage.

#### EXPENDITURES.

The work of the Board is conducted under the provisions of several statutes, and for its different departments of work three appropriations are annually made, one for its general work, one for the inspection of food and drugs and a third for carrying out the provisions of chapter 375 of the Acts of 1888, relating to the protection of the purity of inland waters.

The appropriations for these different departments of work during 1893 were as follows : —

|                                                                       |             |
|-----------------------------------------------------------------------|-------------|
| For the general work of the Board, . . . . .                          | \$10,800 00 |
| For food and drug inspection, . . . . .                               | 11,500 00   |
| For work under the provisions of chapter 375, Acts of 1888, . . . . . | 27,000 00   |
|                                                                       | <hr/>       |
|                                                                       | \$49,300 00 |

In addition to these regular lines of work the Board was charged with the duty of investigating the question of a general water supply for the city of Boston and the suburban cities and towns to the distance of ten miles from the city.

For this investigation the Board was authorized to expend a sum not exceeding \$40,000, of which sum there was appropriated in 1893 the sum of \$15,000.

The expenditures under the foregoing appropriations were as follows : —

#### FOR THE GENERAL WORK OF THE BOARD.

|                                             |            |
|---------------------------------------------|------------|
| Salaries, . . . . .                         | \$4,819 96 |
| Printing, . . . . .                         | 1,325 15   |
| Travelling, . . . . .                       | 1,140 70   |
| Special investigations, . . . . .           | 488 78     |
| Postage, . . . . .                          | 207 61     |
| Books, subscriptions and binding, . . . . . | 306 68     |
| Express, . . . . .                          | 220 23     |
| Stationery, . . . . .                       | 152 42     |
| Telephone, . . . . .                        | 127 05     |
| Type-writer and library supplies, . . . . . | 19 30      |
| Office incidentals, . . . . .               | 54 72      |
| Messenger services, . . . . .               | 257 27     |
| Telegrams, . . . . .                        | 7 33       |
| Draughting wood-cuts, . . . . .             | 31 50      |
|                                             | <hr/>      |
|                                             | \$9,158 70 |

#### FOR FOOD AND DRUG INSPECTION. FOR YEAR ENDING SEPT. 30, 1893.

|                                                        |             |
|--------------------------------------------------------|-------------|
| Salaries of analysts, . . . . .                        | \$4,400 00  |
| Salaries of inspectors, . . . . .                      | 3,900 00    |
| Travelling expenses and purchase of samples, . . . . . | 1,661 75    |
| Apparatus and chemicals, . . . . .                     | 235 63      |
| Rent at Harvard Medical School, . . . . .              | 125 00      |
| Chemical analysis (by other chemists), . . . . .       | 2 00        |
| Furniture and fittings at laboratory, . . . . .        | 26 52       |
| Legal services, . . . . .                              | 45 00       |
| Printing, . . . . .                                    | 4 85        |
| Gas, . . . . .                                         | 33 36       |
| Extra services, . . . . .                              | 20 00       |
|                                                        | <hr/>       |
| Total, . . . . .                                       | \$10,454 11 |

EXPENSES UNDER CHAPTER 375 OF ACTS OF 1888. PROTECTION OF PURITY OF  
INLAND WATERS. FOR CALENDAR YEAR 1893.

|                                                                       |                    |
|-----------------------------------------------------------------------|--------------------|
| Salaries, including wages of laborers at Lawrence Experiment Station, | \$22,743 40        |
| Apparatus and materials,                                              | 1,896 73           |
| Rent of rooms at Massachusetts Institution of Technology,             | 900 00             |
| Rent of Lawrence Experiment Station,                                  | 125 00             |
| Travelling expenses,                                                  | 195 81             |
| Express charges,                                                      | 420 95             |
| Use of tools and office, Lawrence Experiment Station,                 | 412 32             |
| Printing,                                                             | 74 54              |
| Stationery and drawing materials,                                     | 86 21              |
| Maps, blue prints and photographs,                                    | 54 06              |
| Furniture,                                                            | 43 00              |
| Paid for collecting samples of water,                                 | 8 25               |
| Postage stamps,                                                       | 27 90              |
| Messengers and telegrams,                                             | 7 82               |
| Total,                                                                | <u>\$26,995 99</u> |

FOR EXPENSES IN INVESTIGATION OF WATER SUPPLY OF BOSTON AND SUB-  
URBAN TOWNS.

[ACTS OF 1893, CHAPTER 450.]

|                                                                             |                    |
|-----------------------------------------------------------------------------|--------------------|
| Salaries,                                                                   | \$7,455 83         |
| Services and expenses, experts,                                             | 162 25             |
| Apparatus and repairs, borings, drawing and surveying instruments,<br>etc., | 1,249 00           |
| Travelling expenses and board of employés,                                  | 1,200 68           |
| Maps, etc.,                                                                 | 43 50              |
| Stationery and account books,                                               | 71 20              |
| Hardware, hose, pump, pipe, etc.,                                           | 596 87             |
| Lumber,                                                                     | 45 34              |
| Freight, express, etc.,                                                     | 15 99              |
| Office rent and incidentals,                                                | 72 27              |
|                                                                             | <u>\$10,912 93</u> |

A statement of the expenditures relating to the exhibit of the  
Board at the World's Columbian Exposition may be found on page  
xxiii.

H. P. WALCOTT,  
J. W. HASTINGS,  
H. F. MILLS,  
F. W. DRAPER,  
G. C. TOBEY,  
J. W. HULL,  
C. H. PORTER,

*State Board of Health.*



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# WATER SUPPLY

AND

# SEWERAGE.

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ADVICE TO CITIES AND TOWNS.

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## WATER SUPPLY AND SEWERAGE.\*

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[Report required by the provisions of chapter 375 of the Acts of 1888, entitled "An Act to protect the purity of inland waters, and to require consultation with the State Board of Health regarding the establishment of systems of water supply, drainage and sewerage."]

The following report contains the substance of the replies made by the Board to those cities, towns, corporations and individuals which have applied to the Board for its advice relative to systems of water supply, drainage and sewerage, under the provisions of chapter 375 of the Acts of 1888. It also includes a summary of the work done by the Board in connection with the examination of water supplies and rivers, and the purification of sewage.

As one result of the studies of the Board, in connection with the investigations made at the Experiment Station, there has been constructed during the past year by the city of Lawrence a filter-bed covering an area of two and a half acres which now filters the domestic water supply for about 47,000 people. This water supply is derived from the Merrimack River, which receives the drainage of a large part of New Hampshire, and the sewage of Lowell enters only nine miles above the intake of the Lawrence water works. There has been in past years a great increase in the number of deaths by typhoid fever in Lowell and in Lawrence in the late fall and winter months, after the disease had spent its force and nearly ceased in the towns and cities up the river.

The studies of the Board led them to conclude that this large number of deaths, often, in Lawrence, exceeding the number in the city of Boston in the same months, was due to disease germs brought down the river and distributed to the citizens in their drinking water; and after making filters at the Experiment Station that removed all the disease germs

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\* The first pages of this report were contained in a report made to the Legislature Jan. 10, 1894 (Senate Document, No. 4). A portion of the report then made, relating to the work done at the Lawrence Experiment Station, is not reproduced, because a more complete account of the work done at this place will be found in a subsequent part of this volume.

put into the water applied to them, the Board advised the city of Lawrence to construct a filter under the direction of the Board, and to purify their drinking water. The filter was commenced in the fall of 1892, and finished, at a cost of about \$65,000, in September, 1893. Since September 20 all the water that has been pumped to the city reservoir has first passed through the filter.

Very frequent examinations of the water show that 98 per cent. of all of the bacteria in the river water applied to the filter are removed directly by it, and in addition to this it removes a large part of the organic matter from the water and converts much of it to mineral matter, thus depriving the remaining bacteria of food material and rendering the conditions of life so unfavorable that the bacteria decrease as the water goes on through the reservoir and through the distributing pipes, until when the water reaches the citizens there remains but one-half of 1 per cent. of the number of bacteria in the river water; that is,  $99\frac{1}{2}$  per cent. of all have been removed.

The experiments of the Board indicate that the small numbers remaining are of a few hardy kinds that are not known to be in any way injurious to health; and leave the strong probability that all the disease-producing germs have been removed.

The result upon the health of the people of Lawrence is very marked and very satisfactory. The number of deaths from typhoid fever in Lawrence for the three months of October, November and December during the past five years has averaged eighteen; the number of deaths this year, since the water has been filtered, in the same three months, has been four.

At the end of the year 1893 all of the 30 cities in the Commonwealth, and 116 towns out of a total of 322, were provided with a public water supply. The total population of the communities having a public water supply is 87.1 per cent. of the total population of the State.

There are now but 6 towns which, by the census of 1890, had a population exceeding 4,000, which are not provided with a public water supply. The names of these towns, with their respective populations in 1890, are as follows: Black-

stone, 6,138; Ipswich, 4,439; Millbury, 4,428; Winchendon, 4,390; Rockport, 4,087; and Barnstable, 4,023.

Twenty-eight cities and 67 towns, having together a total population of 1,704,510, own their water works, while 2 cities and 49 towns, with a total population of 244,945, are supplied by private companies.

The flow of the streams in the year 1893, taken as a whole, as indicated by the volume of water flowing in Sudbury River, has been a very little below the average for a long series of years; but the seasonal distribution of the flow has been very uneven, the year resembling in this respect 1891. During the four months from February to May, inclusive, the flow was 23 per cent. above the average, and greater than in all but three of the previous eighteen years. On the other hand, the flow for the six months from June to November, inclusive, was 46 per cent. below the average for these months, and there were only four years of the previous eighteen when the flow during the same months was lower.

A year of this unusual character affects very differently different classes of water supplies. Those communities having sufficiently capacious ponds or reservoirs to store the whole amount of water flowing in the spring, obtained for use about the average yield of their sources of water supply; while those provided with smaller ponds or reservoirs, so that they could not prevent the spring flow of the streams from running to waste, felt much more severely the effect of the drought of the succeeding six months. The city of Boston practically exhausted the water in its Sudbury River reservoirs, but the fall rains fortunately came in season to prevent any shortage of water. Mystic Lake, which supplies Charlestown, Somerville, Chelsea and Everett, was reduced to so low a level that temporary pumps were used for a short time to pump water from the lake into the aqueduct.

These are only examples of what occurred in many places in the State. In the southern part of the State there was even less rain than in the eastern part, and some places, of which Southbridge and Uxbridge may be mentioned as examples, entirely exhausted the water from their usual sources of supply, and were obliged to resort to pumping water from the neighboring rivers, thus introducing into the pipes water of undesirable quality.

The State Board of Health was authorized and directed, by chapter 459 of the Acts of 1893, to investigate, consider and report to the Legislature of 1895 upon the question of a water supply for the city of Boston and its suburbs within a radius of ten miles from the State House, and for such other cities and towns as in its opinion should be included in connection therewith.

The experience of the past year has emphasized the urgent need of a new water supply for this district, as not only has the water supply of Boston and the district supplied from Mystic Lake been nearly exhausted, as above indicated, but the water supplies of a majority of the places in the Metropolitan district have been in a similar condition.

The Board began considering the subject of a water supply for the Metropolitan district seven years ago, by collecting information of a general character with regard to the various sources which might furnish a water supply for this district, and by determining the exact quality of the water of the different sources by a series of analyses covering a period of two years or more.

Owing to these preliminary studies, the Board was enabled to begin at once, after the passage of the act above mentioned, to enlarge its staff of engineers, and to make surveys and examinations with a view to determining definitely the capacity of different sources and the cost of obtaining a water supply from them.

While it is too early to present any conclusions regarding the best source of water supply for the district, it may be said that the investigations made up to the present time indicate that an abundant supply of good water for the Metropolitan district may be obtained without excessive expenditure.

The comparatively low stream-flow of the last three years has made the question of additional water supplies for many towns extremely urgent, and the advice of the Board as regards the capacity and fitness of new sources of supply has been repeatedly sought. The constantly increasing fund of information which the Board is acquiring through its staff of engineers, chemists and biologists, concerning the characters of the natural waters of the State, puts it in

position to give advice, in many cases, with a certainty and promptness that was not possible before these investigations were undertaken.

The chemical and microscopical analyses of the waters of the State have been continued during the year 1893, 1,731 samples of water having been examined. These examinations include many of the regular water supplies of the State, but a very much larger number of examinations than ever before has been made of waters proposed for new supplies of cities and towns.

Following is a classified list of the waters examined during the year : —

|                                                                                                                                           |       |       |
|-------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|
| From open and covered reservoirs for the storage of ground waters, . . . . .                                                              | 26    |       |
| From ground-water supplies, . . . . .                                                                                                     | 294   |       |
| Special investigations of regular water supplies affected by tastes, odors, etc., . . . . .                                               | 16    |       |
| From ponds and storage reservoirs and their inlets, . . . . .                                                                             | 578   |       |
| From streams and miscellaneous sources, . . . . .                                                                                         | 127   |       |
|                                                                                                                                           | <hr/> |       |
| Total from regular water supplies, . . . . .                                                                                              |       | 1,041 |
| In connection with investigations of new sources of water supply, . . . . .                                                               | 230   |       |
| With reference to pollution of streams, . . . . .                                                                                         | 155   |       |
| With reference to sewage purification at Framingham, Marlborough, Gardner, Medfield, Westborough, Lenox, Amherst and Wellesley, . . . . . | 251   |       |
| In connection with the study of epidemics, . . . . .                                                                                      | 18    |       |
| Miscellaneous, . . . . .                                                                                                                  | 36    |       |
|                                                                                                                                           | <hr/> | 690   |
| Total, . . . . .                                                                                                                          |       | 1,731 |

The microscopic vegetable and animal organisms have been determined as usual in all the waters which have been examined chemically, and our knowledge of the connection between these organisms and the tastes and odors of the waters, has been somewhat increased.

The continued investigation of the efficiency of sewage purification throughout the State by the chemical and biological examination of sewages and effluents, and by the mechanical analysis of soils, has afforded important results, which, taken in connection with the experimental work at

the Board's Experiment Station at Lawrence, can be directly utilized in determining rules of practice for the purification of sewage by intermittent filtration on a large scale. A very large number of examinations of sewage and effluents has been made from the purification fields at Framingham, Marlborough, Gardner, Medfield, Westborough, Lenox and Wellesley. No sanitary question is of greater or more immediate importance than the disposal and purification on land, of the sewage of cities and towns. To do this effectively and harmlessly, an intelligent control of the process is needed for each situation.

In connection with the study of new sources of supply, a large number of ground waters has been examined, with the result of adding much to our knowledge of the subterranean waters of the State. In the report for 1892 attention was directed to the presence of iron in some ground waters, which made them very objectionable for domestic use. During the past year the metal manganese has been found in well waters at Watertown in considerable amount, associated with organic matter. The sanitary significance of this occurrence has yet to be determined.

In previous reports of the Board attention has more than once been drawn to the fact that the deeper layers of water in ponds were stagnant during the warmer months, and that when the bottom of the pond or reservoir contained decomposable organic matter the water near the bottom became very foul with the products of putrefaction. In the case of Lake Winnipiseogee, samples taken during August at a depth of 110 feet from the surface showed the water to be of the same quality and composition at the bottom as at the surface.

Analyses of soils from a proposed storage reservoir have been made to determine the amount of stripping which would be necessary to remove all the organic matter from the surface before filling the reservoir with water. The cleaning of the bed and sides of a reservoir is now known to be essential if the water contained in it is to be preserved free from putrefactive products in summer; but the depth to which the surface soil should be removed can be best learned by a direct determination of the organic matter in the different layers. The results of the analyses in this case are interesting and valuable.

An extended series of analyses of the water of the lower Charles River has been made during the year to determine the amount of its pollution by sewage and manufacturing wastes, and also to determine the influence of the flood tide in backing up the impure water.

During the year the artificial ice made for sale in the State has been investigated, chemically and biologically. A special report on the subject was made to the General Court on May 16, 1893.

Of the sewage filters at the experiment station, several of those that had been in use for five or six years had for a year or more been subject to treatment known to be unlikely to give the best results, but tried for the purpose of learning the result of peculiar methods of treatment, and the effluent was not as well purified as in former years. Upon restoring the old filters to their normal condition and treating them by the methods which had been found most favorable for complete purification they resumed their former ability, and gave as satisfactory effluents, both in quality and quantity, as in former years.

In the filtration of sewage remarkable results have been obtained through the past year, by first filtering sewage very rapidly (nearly five hundred thousand gallons per acre daily) through gravel stones through which air was also being constantly drawn; and then again filtering this effluent through sand at the rate of about one million gallons per acre daily. By the first filtering about 82 per cent. of the albuminoid ammonia and the same percentage of the bacteria were removed; and at the end of the second filtering there remained in the effluent but  $2\frac{1}{2}$  per cent. of the albuminoid ammonia of the sewage and but two one-hundredths of 1 per cent. of the bacteria. By this method of first burning up the sludge by the help of the current of air drawn through the gravel stones nearly three times, as much sewage may be nitrified and purified with a given area of surface as has been previously purified by sand filtration.

It is desirable that experiments upon this method of filtration be continued and its limits determined.

Very good effluents have also been obtained by rapid filtration through sand of the supernatant liquid after sewage has



settled naturally and after the sludge has been precipitated by chemicals.

In water filtration very satisfactory results in the removal of bacteria have been obtained when filtering at much higher rates than formerly, even up to nine million gallons per acre daily. These results indicate the desirability of further experiments to determine under what conditions satisfactory removal of disease germs may be assured when filtering at more rapid rates.

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### ADVICE TO CITIES AND TOWNS.

Under the provisions of chapter 375 of the Acts of 1888, entitled "An Act to protect the purity of inland waters, and to require consultation with the State Board of Health regarding the establishment of systems of water supply, drainage and sewerage," the Board is required "from time to time to *consult with and advise the authorities of cities and towns, or with corporations, firms or individuals either already having or intending to introduce systems of water supply, drainage or sewerage, as to the most appropriate source of supply, the best practicable method of assuring the purity thereof or of disposing of their drainage or sewage, having regard to the present and prospective needs and interests of other cities, towns, corporations, firms or individuals which may be affected thereby.* It shall also from time to time consult with and advise persons or corporations engaged or intending to engage in any manufacturing or other business, drainage or sewage from which may tend to cause the pollution of any inland water, as to the best practicable method of preventing such pollution by the interception, disposal or purification of such drainage or sewage: *provided, that no person shall be compelled to bear the expense of such consultation or advice, or of experiments made for the purposes of this act. All such authorities, corporations, firms and individuals are hereby required to give notice to said Board of their intentions in the premises, and to submit for its advice outlines of their proposed plans or schemes in relation to water supply and disposal of drainage and sewage;*

*and all petitions to the Legislature for authority to introduce a system of water supply, drainage or sewerage shall be accompanied by a copy of the recommendation and advice of the said Board thereon."*

During the year 1893 the Board has given its advice to the following cities, towns, corporations and individuals who have applied for such advice under the provisions of the general act of 1888, or under special acts relating to water supply and sewerage.

Replies were made during the year to applications made from the following sources for advice relative to water supply: Arlington, Canton, Chester, Fairhaven, Falmouth Heights, Holyoke, Hyde Park, Kingston, Lawrence, Lexington, Lowell, Lynn, Marlborough, Medford, Melrose (three replies), Mendon, Methuen (two replies), Newburyport (two replies), North Andover, Peabody, Rockport, Salem, Saundersville (Grafton), Scituate, Sharon, Southbridge (two replies), South Deerfield, Stoughton, Uxbridge, Wakefield, Walpole (two replies), Waltham, Webster, Westborough, West Springfield, Whitman.

Replies relating to sewerage and sewage disposal were made in response to applications from the following sources: Andover, Attleborough, Braintree, Brockton (two replies), Framingham, Holyoke, Leicester (three replies), North Brookfield, Pittsfield, Plymouth, Spencer and Westborough.

#### WATER SUPPLY.

The following is the substance of the action of the Board in reply to applications for advice relating to water supply:—

**ARLINGTON.** The committee on water supply of the town of Arlington applied to the State Board of Health, Dec. 24, 1892, for advice relative to the best method of obtaining a water supply for the higher portions of the town, which cannot be supplied from the present service, and of improving the quality of the present supply. The attention of the Board was particularly called to a plan for pumping water from driven wells, on the borders of the great meadows and near the East Lexington railroad station, to a reservoir at a

sufficient height to supply the high portions of the town. The Board replied as follows : —

Boston, Feb. 10, 1893.

In order to ascertain the quality of water from these wells, the Board has caused analyses to be made of the five samples sent in by you. These samples showed the presence of an unusually large amount of free ammonia for a ground water and a larger amount of iron than is commonly found, both of which were probably due to the proximity of the wells to the Great Meadows. Notwithstanding these characteristics, if the water drawn from this source should continue to be as good as the samples, there is no doubt that it would be satisfactory for all water-supply purposes, and very much better than the water at present supplied to Arlington. The great danger, however, is that with continued pumping the water will be derived to an increased extent from the meadow by filtration through the peaty material, and will deteriorate and become unsatisfactory.

It is obvious from an inspection of the locality where the wells are driven that very little if any water can come from the easterly or down stream side of the wells owing to the presence of rock and other impervious material, and the fall of the ground in this direction. In other directions from the wells the character of the upland which might contribute ground water to them is such that a large portion of the water flows off into the meadows, and only a comparatively small amount soaks into the ground, near enough to the wells so that it will percolate directly to them. If any large quantity of water is to be obtained from the wells, the supply must necessarily be derived from the meadow by the filtration of water through it into the ground beneath, and under such circumstances it is extremely doubtful if the supply will continue to be of satisfactory quality.

With regard to the quantity of water to be derived from this source, the character of the material encountered by the test wells and the results obtained by the pumping test seem to indicate that the ground in the immediate vicinity of the wells is of favorable character for obtaining a ground water supply. The tests have not been sufficiently extended, however, to determine from how large a territory wells at this place will draw water or how much water can probably be obtained from this source. Even if the wells should draw water from a very considerable distance, so that all the water now coming into the Great Meadows could be utilized, the average daily supply in a dry year could hardly be expected to exceed 200,000 gallons per day ; but if the water filtering through the peaty material of the Great Meadows should prove to be of

satisfactory quality the supply might be increased by diverting into the meadows some of the water from the upper half of the main watershed, which would otherwise run to waste during the spring over the dam of the main reservoir.

Taking everything into consideration the Board is of opinion that the chances are against getting a satisfactory supply from the proposed source either as regards quantity or quality, though some of the doubts which now exist might be removed by more thorough tests of this source if it were thought advisable to make them.

In view of the unfavorable outlook for obtaining a satisfactory supply from the source already tested near the Great Meadows, the Board has caused examinations to be made by its engineer of other portions of the watershed from which your water supply is derived. Judging from the surface indications he finds that some of the land in the vicinity of the main brook which feeds your reservoir promises to furnish a larger supply of ground water of good quality than any other place upon the watershed, and the Board would therefore advise that you make further tests in this vicinity. It is desirable to locate a well or wells quite a long distance, say one-fourth of a mile or more, above the present reservoir but not so far up stream as to be above the ridge, through a cutting in which Munroe Brook flows into the stream which supplies your reservoir. It is also desirable to avoid the immediate vicinity of any large swamp, and to select a place where the porous material from which water can be pumped freely extends to a considerable depth, say from thirty to fifty feet.

In addition to the question of obtaining a supply from the ground your application also refers to the deepening of the present reservoir with a view to improving the quality of the water.

The disagreeable character of the water drawn from the reservoir at times last year and also on previous occasions is caused by the growth and decay of minute vegetable forms, and these in turn grow in greater abundance when the water contains an abundant supply of nitrogenous food. Experience has shown that this supply of food may be derived from organic matter in the bottom of the reservoir or it may come into the reservoir in the water which supplies it. In the present case the supply of food for these minute organisms may be derived from both these sources, as there is a considerable amount of organic matter in the bottom of the reservoir, and analyses show that the water of the brook entering the reservoir contains a liberal supply of nitrogen, a result which might be expected from the population upon the watershed and the heavy manuring of portions of it.

The removal of all mud from the reservoir and the deepening of

the shallower portions would undoubtedly have a decided tendency to improve the character of the water. Of these improvements, however, the removal of the mud is of greater importance than the deepening of the shallower portions of the reservoir where it has a gravelly bottom; still, both of them are very desirable. There can be no certainty, however, of any radical change for the better in the quality of the water, as these improvements would only remove one of the causes of the minute vegetable growths.

**CANTON.** The water commissioners of Canton requested the advice of the State Board of Health, March 29, 1893, as to the propriety of taking an additional supply of water from the valley of Beaver Brook. To this application the Board replied as follows:—

Boston, June 2, 1893.

The State Board of Health has considered your application with regard to an additional water supply, to be taken from the valley of Beaver Brook above your present pumping station, in accordance with the report of your engineer, submitted with said application.

The report above mentioned contains the results of investigations made at various points in the valley of Beaver Brook above the present pumping station. The nearest point at which the investigations indicated the existence of a valuable additional supply is half a mile above the present pumping station, in an extensive meadow and swamp lying above Pleasant Street. Other investigations were made about a mile above the pumping station in what are known as the Ponkshire Meadows and from this point up to the vicinity of the Henry Springs, so called, and the question of taking an additional supply from Dead Meadow Brook and from York Pond, which lies at the head of Beaver Brook, was also considered.

All of these sources except the Ponkshire Meadows may furnish a valuable additional supply in the future, but the investigations in the meadow above Pleasant Street indicate that a sufficient additional supply of good water for the present may be obtained from this source alone.

The plan proposed by your engineer to meet all present requirements consists of a large collecting well about 2,600 feet above the present well, and connected with it by means of a twelve-inch pipe laid at a considerable depth below the surface of the ground. It is also proposed by him to extend pipes above the new well and to connect driven wells with them to furnish additional water.

Ten test wells were driven in the immediate vicinity of the pro-

posed collecting well and at varying distances from it, and samples of water from a portion of these wells have been analyzed by the State Board of Health. The tests in this vicinity indicate the existence of porous layers beneath the surface, through which water will flow freely; and the samples of water collected in the immediate vicinity of the proposed collecting well were of excellent quality. At a distance of a few hundred feet from this location, however, one sample was collected which contained enough iron to make the water objectionable for domestic uses, and at a somewhat greater distance in another direction an unsatisfactory water was obtained. There is therefore some doubt whether the water at the location of the collecting well will maintain its present good quality when a continuous draft on the well causes the water to flow to this point from all directions. The tests above the collecting well are limited in number and do not enable any definite judgment to be formed as to the character of the water to be obtained from the wells, which, according to the proposed plan, are to be driven to supplement the supply from the collecting well.

Taking the investigations made in this vicinity as a whole, they seem to indicate that it will be feasible to obtain a satisfactory supply of water, but they do not indicate definitely how large a territory will furnish good water, or whether the territory which furnished samples of good water will continue to furnish water of the same quality when a continuous draft is made upon it, nor can the permanent quality of the water be thoroughly tested except by producing this continuous draft, which may be done either by driving wells, connecting them together and pumping from them for a long time, or by laying the proposed main pipe and connecting the driven wells with it so that they will flow continuously. The cost of a pumping test would be so large, without adding anything of permanent value to the works, that the Board advises the laying of the main pipe as proposed by your engineer, and the connection with it of driven wells, substantially as proposed by him, in the territory where the best water can be obtained, and one or two driven wells at the site of the proposed collecting well, but it would not advise the construction of the collecting well until the test wells in its vicinity had shown by running a long time, say six months or a year, that the water from them was not deteriorating in quality. After such test the collecting well could be constructed.

CHESTER. The committee on water supply of the town of Chester applied to the State Board of Health, April 25, 1893, for its advice relative to taking the water of Austin, Walker

and Blandford brooks, in the towns of Chester and Becket, and of Horn Pond in the town of Becket. The Board replied as follows:—

Boston, June 1, 1893.

In response to your application of April 25, 1893, the State Board of Health has caused an examination to be made of four sources of water supply for Chester, namely, the Austin, Blandford, and Walker brooks in Chester and Becket, and Horn Pond in Becket.

Samples of water from all of these sources, collected by you May 22, have been analyzed. All four samples are very soft and there is no choice between them in this respect. In all other respects the analyses of samples from the Austin and Blandford brooks indicate that these waters are very nearly alike in quality, with a slight advantage in favor of the Austin Brook, and that they are decidedly better than the waters of Walker Brook or Horn Pond. An examination of Austin Brook shortly after a heavy rain showed only a moderate amount of turbidity in its water, and the absence of houses and roads upon its watershed are a point in its favor. It is therefore a very desirable source of supply to the extent of its capacity. There is obviously no reason to doubt that it will furnish the town with an ample supply of water for all ordinary water supply purposes except during very dry seasons, and judging from the yield of other mountain streams, in proportion to the territory drained by them, it will furnish a sufficient quantity of water even at such times for these purposes.

The Blandford Brook at its mouth has a watershed about one-half greater than that of the Austin Brook, and in the absence of definite knowledge its summer flow may be assumed to be one-half greater than that of the Austin Brook.

The sample of water from the Walker Brook was, as before indicated, not as good as those from the Austin and Blandford Brooks; still it would be classed as a satisfactory water in towns where there are not so many opportunities for getting a first-class water, and there is no reason now known to the Board why it should not be resorted to should the other sources fail in very dry times to furnish a sufficient supply. At such times it seems probable that the water from this brook might be as good as that from the others, but more definite information upon this point can be obtained by collecting and analyzing a sample of water from the brook when at a low stage.

The sample from Horn Pond indicates that at the time of its collection the water of this source was better than that of the Walker Brook, but not nearly as good as that of the other brooks.

The water of ponds and other quiet bodies of water is liable to be affected at times by growths of minute organisms which affect the taste and odor of the water, and which, though not known to be injurious to health, may at such times render the water unpalatable. This source would furnish a sufficient quantity of water, but owing to the reasons above indicated and to the larger cost of taking water from it on account of its greater distance from Chester, it does not seem to be a desirable source for the town to adopt.

In the following suggestions as to the source to be adopted and the general plan of works the Board necessarily bases its judgment on facts deduced from observations made in other places, and these suggestions may therefore require modification on account of the local conditions affecting the minimum flow of these streams, of which the Board now has no definite knowledge. The suggestions are that Austin Brook should be adopted as a source of supply in any case, and that if a larger amount of water than it will supply is needed it should be taken from the Blandford Brook near its mouth. If a still further supply should ever be needed, which would occur only during very extreme droughts, if at all, it should be taken from Walker Brook. Should water be taken from both the Austin and Blandford brooks it would be desirable to place the inlet at the former slightly higher than at the latter so as to insure taking the supply from the Austin Brook whenever it will furnish a sufficient quantity of water, and thereby prevent the entrance of the water from the Blandford Brook whenever it is affected by the wash from the road near it.

**FAIRHAVEN.** The authorities of Fairhaven applied to the Board, March 10, for advice in regard to introducing a water supply from driven wells in the easterly part of the town, to which the Board replied as follows:—

Boston, May 5, 1893.

The State Board of Health has considered your application dated March 10, 1893, relative to a proposed water supply for the town of Fairhaven, to be taken from driven wells in the valley of the Nasketucket River, a small stream situated about one and a half miles east of the town. At this place six test wells have been driven and are now flowing. Samples of water collected from three of these wells have been analyzed. The analysis of the water from the northeasterly well showed it to be a very pure and very soft water, while the samples from one of the intermediate wells and from the southwesterly well indicated water that had at some time been polluted and again purified by filtration through



the ground. As there are very few houses anywhere near the wells and the whole watershed is very sparsely settled, the inference to be drawn from these results is that the southerly wells intercept a vein of water which has passed near one of the nearer farmhouses. These results should not lead to the rejection of this source on the score of quality, because, not only is the water purified by its passage through the ground, but it is not improbable that when water is pumped from this source continuously it will assume much more nearly the character of the water now flowing from the northeasterly well. It would be advisable, however, in any case, if a supply is taken from this source, to determine from which farmhouse the polluting matter now enters the ground, and prevent such pollution, rather than depend upon the purifying power of the ground.

With regard to the quantity of water to be derived from wells in this locality, the tests made up to the present time do not appear to be conclusive as to whether the supply will be sufficient for the town for any considerable time in the future. Taking into account, however, the results of these tests, the comparative economy of this source on account of its nearness to the town as compared with any source from which it is at all probable that a satisfactory supply can be obtained, the opportunities for supplementing the supply whenever necessary from the Mattapoissett River valley, and the excellent quality of the water which the proposed source may be expected to furnish with proper care to prevent pollution, the Board is of opinion that this source is a proper one from which to take at the present time a water supply for Fairhaven.

It has been found by experience in this State that wells encountering ledge within 20 to 30 feet of the surface do not furnish as large a quantity of water as where the ledge is at a greater depth, and the Board therefore advises you to make further tests of the ground in this vicinity before locating the permanent wells in order to ascertain if a place cannot be found where the ground is porous enough to furnish water freely and where the ledge is at a greater depth than at the present location.

**FALMOUTH HEIGHTS.** The Falmouth Heights Water Company applied to the Board, June 13, for advice relative to taking a supply of water from a well or wells on the premises of the company at Falmouth Heights, a summer resort in Falmouth, upon Vineyard Sound. The Board replied as follows:—

BOSTON, July 6, 1893.

In reply to your application dated June 13, 1893, relative to a proposed water supply for the summer settlement known as Fal-

mouth Heights, in the town of Falmouth, the State Board of Health has caused an analysis to be made of a sample of water from a well sunk in one of the parks at the Heights, a few hundred feet north of Observatory Hill, and finds that the water is at present of excellent quality for water supply purposes.

Without further information the Board is unable to advise in regard to the quantity of water that can be obtained, and it should be examined after continued use that its permanent character may be determined.

**HOLYOKE.** The water commissioners of Holyoke applied to the Board, June 13, for its advice relative to taking the water of Munn Brook, in the town of Granville, as an additional water supply for the city. The Board replied to this application as follows:—

Boston, Oct. 5, 1893.

The State Board of Health received from you on June 13, 1893, an application for advice with regard to an additional water supply for the city of Holyoke, accompanied by a plan for taking water from Munn Brook in the town of Granville, through a pipe 20 inches in diameter, to Ashley Pond, one of the present sources of water supply of Holyoke.

The Board has caused an examination of the watershed of Munn Brook to be made, also an analysis of a sample of water collected from the brook near the proposed point of taking.

These examinations indicate that the water is soft and naturally of very good quality; but it is at present polluted at a few points by the discharge of sewage into it.

This pollution should be stopped before the water is taken for use, and as an additional precaution it is desirable that the water should be diverted into Ashley Pond rather than be allowed to run directly from the stream through the pipes into the city.

The amount of water which this source will furnish with a 20-inch pipe connection to Ashley Pond is so limited that the Board would advise the use of a pipe not less than 24 inches in diameter; and even with a connection of this size, the brook will not furnish, in very dry seasons, a sufficient additional supply for any long term of years in the future if the city continues to grow as it has in the past, unless capacious storage reservoirs are built upon it or its branches.

Certain sites for reservoirs have been indicated, but the information furnished with regard to their character, capacity, and cost is too limited to warrant an opinion as to whether it is desirable to

construct them. It has been shown, however, that it is feasible to supplement the supply to be obtained from Munn Brook by a comparatively short connection from the Westfield Little River; so that if Munn Brook should prove insufficient, there may be an opportunity to obtain a further supply from this river.

The Board has also caused an examination to be made, in a general way, of other available sources, among which may be mentioned the Westfield Little River above referred to, and Bachelor Brook in Granby, both of which would furnish more water than Munn Brook; the former by gravity, and the latter by pumping.

. Neither of the three sources which have been mentioned has such a distinct advantage over the others as to enable the Board to advise, with the information now available, as to which is the most appropriate source of water supply for Holyoke.

It is obvious that a further water supply for Holyoke is urgently needed; and in view of the fact that an adequate additional supply will necessarily require a large expenditure of money, the Board advises you to have made, as promptly as possible, with the assistance of an engineer skilled in water supply investigation, a much more thorough investigation of the available sources than has yet been made.

When this additional information is received, the Board will advise you further in this matter.

Accompanying this reply will be found a table of analyses of samples of water collected from various sources.

The water of streams varies so much from time to time that it will be advisable to have further analyses made as a basis for forming a judgment as to the relative quality of water from the different sources. The Board will cause these analyses to be made, if you will provide for collecting the samples.

**HYDE PARK.** The Hyde Park Water Company applied to the Board, May 26, for advice as to the propriety of increasing their present supply of water by the use of driven wells north of their present driven well system. The Board replied to their application as follows:—

BOSTON, June 14, 1893.

The State Board of Health has received and considered your application dated May 26, 1893, asking it to examine and report upon the quality of water from a new system of driven wells, located just north of the present driven well system in Hyde Park.

Samples of water have been collected and analyzed from three wells of this system, one being the well nearest the river, another

a well near the middle of the system, and a third the well farthest from the river. These samples were all collected by pumping with a hand pump. The water from the well nearest the river (well No. 5) gives the same indications of imperfect filtration which are characteristic of water from the starch factory well, though not to so great an extent. This water would not be of satisfactory quality for water supply purposes. The samples from the intermediate well and from the one farthest from the river (wells Nos. 14 and 36) resemble in character the water taken from your present driven well system five or six years ago and are of satisfactory quality. Just what the effect will be of continuous pumping from the wells which now furnish good water cannot be foretold with certainty. The general experience under these circumstances, however, is that the water will deteriorate. The Board would therefore advise that if you take any water from the new system of wells each well should be provided with a gate so that it can be shut off if it furnishes water of unsatisfactory quality, and frequent tests should be made to determine whether or not the water is deteriorating.

It is very desirable that in increasing your supply in the vicinity of your present pumping station water should be taken from the ground as far from the river as suitable porous material can be found.

KINGSTON. The water commissioners of Kingston applied to the Board, June 9, for its advice relative to increasing their water supply by taking the water of Jones River, in case their present ground-water supply should prove insufficient. The Board replied as follows:—

Boston, July 6, 1893.

The State Board of Health received from you on June 9, 1893, an application with regard to using water from Jones River this summer for an additional water supply if the supply from the present well and filter-gallery should prove insufficient.

The Board caused samples of water collected from Jones River at Kingston in October, 1887, and in February, 1890, to be analyzed, and these analyses indicate that the water has a rather dark color, owing to the drainage from swamps on the watershed, and that it would not be wholly satisfactory to the consumers either in taste or appearance. With regard to its relation to the health of the consumers it may be said that in a case like this a chemical analysis of the water is not a trustworthy guide. The experience of the Board has shown that a *running stream* which receives sew-

age above the point where the water is taken from it is one of the most dangerous sources of water supply; because, if the infection of any specific disease is turned into the stream, it is much more likely to be conveyed to the water works intake and thence to the consumers before it loses its virulence than if the sewage entered a large pond or reservoir where there is no current.

The advice of the Board is therefore that the town of Kingston should not use the water of Jones River even temporarily without first ascertaining by an actual inspection of the main stream and its tributaries that no sewage is turned directly into them; and it is the further opinion of the Board that this river is not an appropriate source from which to take a permanent water supply for Kingston.

**LAWRENCE.** Application was received from the Lawrence water board for information in regard to the results of filtration of the water supply of the city through the filter covering two and a half acres, built by the city during the past year at an expense of about \$65,000.

The water supply is drawn from the Merrimack River about nine miles below the entrance of the sewage of the city of Lowell, and for many years typhoid fever had prevailed in Lawrence to the extent of three times the average of the cities of the State, and following six or eight weeks after its prevalence in Lowell.

Under date of December 5, the following reply was made:—

The filter bed built by the city of Lawrence under the advice and in accordance with plans of the State Board of Health, has been steadily purifying the water supply of the city since the twentieth of September.

When commencing to construct the filter, you were advised that “with such a filter, properly managed, the experiments of the Board of Health indicate that at least 98 per cent. of all of the bacteria of the river water will, under all circumstances, be removed.” During the past two months the filter has been removing this percentage of all the bacteria of the river water, but this is not all that it accomplishes; it removes a large part of the organic matter of the river water and converts it to mineral matter, thus removing from the water the food material which the bacteria live upon, and the result is that the two per cent. of bacteria remaining after the water has passed through the filter find their condi-

tions of life so unfavorable that they decrease as the water goes on through the reservoir and through the distributing pipes, until when the water reaches the citizens there remains but one-half of one per cent. of the number of bacteria in the river water, that is, ninety-nine and one-half per cent. of all have been removed.

The experiments of the Board indicate that the small number remaining are of a few hardy kinds that are not known to be in any way injurious to health, and leave the strong probability that all disease-producing germs have been removed.

It will be a satisfaction to the citizens to know that while for the past five years the number of deaths by typhoid fever in Lawrence has averaged five for the month of October and five for the month of November, the number of deaths this year has been only one for each of these months.

**LEXINGTON.** The water company of Lexington applied to the Board, February 15, for its advice relative to an additional water supply, and the Board replied as follows:—

BOSTON, May 4, 1893.

The State Board of Health has considered your application, dated Feb. 15, 1893, asking the advice of the Board in regard to an additional water supply for the town of Lexington. This application was accompanied by the report of the civil engineer employed by you to make investigations for an additional water supply for the town, and by a plan prepared by him of proposed storage reservoirs on Vine Brook, above your present works. The attention of the Board was subsequently called by you to the covered gallery, built last year, for the collection of ground water, in the sandy plain near the village, and connected with your present ground water sources.

The report of your engineer relates to examinations for a supply from entirely new sources as well as to augmenting the present supply by additional works within the territory from which it is derived. The examinations for new sources were made in a westerly or north-westerly direction from the central village of Lexington, in territory from which the water drains toward the Shawsheen River in the town of Bedford, and extended to a point nearly two and a half miles from the village. The larger streams within this territory will not furnish directly a water of satisfactory quality for the purposes of a public water supply, and the smaller streams at the points where the water is good will furnish so little water that it would be difficult, if not impracticable, to obtain from them a sufficient quantity of water for Lexington. The test wells

driven under the direction of your engineer within this territory give unfavorable indications with regard to obtaining a satisfactory ground water supply from it.

The difficulty of obtaining a supply from any new source about Lexington, as indicated by the special examinations of your engineer in the territory mentioned, and a general examination of other possible sources, seems to warrant the adoption of measures for developing the present supply which might not be warranted if a much better source could be obtained within a reasonable distance from the town.

It is understood that your present ground water sources now furnish an ample supply of water during all but the dryer portions of the year, and that the reservoirs shown upon the plan submitted are intended to supply the deficiency at such times. The lower of the two reservoirs is considerably further up stream and about five times as large as the one proposed by you in 1891, and referred to unfavorably in the reply of the Board to you dated April 7th of that year. The present location is much better than the old one, but, owing to the fact that some of the land above the reservoir is cultivated, and that so small a quantity of water will flow into it owing to the limited size of its watershed, much care will have to be taken to maintain the water in a pure and satisfactory condition. In the preparation of the reservoir all soil and vegetable matter should be removed from its bottom and sides, and the shallow portions should be deepened. A liberal amount of land should be acquired around the reservoir for its protection, and suitable arrangements should be made to prevent any washings from manured fields from flowing into it. It would also be necessary to take proper measures to prevent any contamination of the water by the drainage from a large stable at the extreme upper end of the watershed.

The upper reservoir is less satisfactory than the lower one as it is shallow and has so small a watershed that the water would stand in it a very long time before being replaced by fresh water, and it would probably become unfit for use. If, therefore, you decide to increase the supply by storing the surplus water which flows off during the wetter portions of the year, the Board would advise that the upper reservoir should not be constructed and that the lower one should be enlarged as much as possible by locating the dam somewhat further down stream, and by excavating within the reservoir. The suggestion of your engineer that "some additional ground water might be brought into the pump well by laying an open-jointed sub-drain in the trench with the leading main from the reservoir, making the joints tight wherever the pipe passed

through a muck deposit," is one worthy of adoption should the portion of the pipe trench through the sandy land toward the proposed reservoir be found to furnish water freely.

An analysis has been made of a sample of water collected from your covered gallery near the village, and the water is at the present time of satisfactory quality for domestic use. At the time the sample was collected water was not being drawn from this source, and as its quality may change when there is a draft upon it you are requested to notify the Board when you begin to use it, and further examinations will be made.

**LOWELL.** The Water Board of Lowell applied to the State Board of Health, May 9, for its advice relative to taking an additional supply of water from the valley of River Meadow Brook in the south part of Lowell. The Board replied as follows:—

Boston, May 16, 1893.

Samples of water from driven wells in this locality were sent in to the Board by your engineer last autumn, and the water was then found upon examination to be of excellent quality for all the purposes of a public water supply. This portion of the city, however, is growing rapidly and in order to maintain the purity of the water, if a supply is taken from this source, the city should control the land for a considerable distance from the wells in all directions so as to prevent the construction of buildings near them, and should extend the sewerage system of Lowell so as to carry away from all buildings the sewage which might otherwise find its way by filtration through the ground into the wells.

The time within which you desire a reply is too limited to permit the Board to make sufficiently extended investigations to serve as a basis for an opinion as to the quantity of ground water which can be obtained from the valley of this brook within the limits of the city of Lowell, nor does such an opinion seem necessary at the present time when you are constructing extended works by which the capacity of this source can be tested.

**LYNN.** The mayor of Lynn applied to the State Board of Health, January 31, for its advice relative to taking the water of Saugus River and its tributaries as an additional supply for Lynn. The Board replied as follows:—

Boston, April 4, 1893.

The application is not limited to any particular portion of the river and its tributaries, but the attention of the Board has been



directed chiefly to the territory above Howlett's dam, to which the works of the Lynn water supply now extend. Above this point on the river are situated the towns of Wakefield and Reading which turn so much polluting matter into the streams as to render the Saugus River at this point an unfit source from which to take a water supply, unless the water is very thoroughly purified by filtration. This polluting matter enters Quannapowitt Lake and its tributaries and the streams which flow through Wakefield and enter the river below the town. If these polluted waters were diverted, those coming from the remaining portions of the watershed would be comparatively free from pollution by sewage.

No extended chemical examinations of these unpolluted sources have been made, with the exception of Pilling's Pond, but judging from an examination of the water at this season of the year and a few previous analyses, it seems probable that some of the water, particularly that from the river itself, would be unsatisfactory for water supply purposes, owing to the large amount of swampy land with which the water comes in contact, thereby making it very dark in color and giving it a peaty taste and odor.

Pilling's Pond is an artificial millpond made by flowing a meadow to a depth of four feet. The State Board of Health in 1888 advised the Revere Water Company that this pond was not a suitable source of supply for the towns of Revere and Wintthrop, owing principally to the fact that if used as a principal source of supply it would necessarily be drawn very low in the summer. The water, however, is of fairly good quality considering the very small depth of the pond and it might be used by Lynn in connection with present sources until a better supply can be obtained.

There is a very large amount of flat land adjacent to the river between the dam at Montrose and Lake Quannapowitt and it seems not improbable that a valuable ground water might be obtained from this territory, although there are no means of determining at all definitely at the present time either the quantity or the quality of water which could be obtained. It is not improbable, however, that the quality of the ground water would be very much better than any surface water supply from this vicinity and the quantity may be as large as would be furnished by the surface water sources after excluding the polluted water of Lake Quannapowitt and the brook which receives the drainage of Wakefield.

The Board recognizes the gravity of the present situation of the Lynn water supply and would therefore advise that provision should be made at the earliest possible moment for supplementing the present supply with the best water which can be obtained from the Saugus River watershed.

In order to provide any other than a very temporary supply of potable water from the Saugus River valley, it is obvious that the works must necessarily be somewhat complex and expensive, and it is not at all probable that a fairly permanent supply can be obtained from this source. The Board would therefore advise that before entering upon any extensive works in this valley, the whole subject of a further water supply from this valley, and from other available sources, should be carefully investigated. One of the first points in such an investigation should be the examination of the territory near the river, between the Montrose dam and the next dam above, with a view to obtaining a ground water supply.

The Board has now before it an application from the Wakefield Water Company, asking for advice with regard to an additional water supply for the towns of Wakefield and Stoneham, to be taken from filtering galleries, wells or basins, upon the banks of that portion of the Saugus River lying within the limits of the town of Wakefield, above the milldam at Montrose. The Board is aware of the fact that the Wakefield Water Company has practically reached the limit of capacity of Crystal Lake, its present source of supply, and that the other source, viz., Lake Quannapowitt, from which the water company was originally authorized to take a further supply, is not of suitable quality for water supply purposes. It is therefore of opinion that the right of Lynn to take water from the Saugus River valley should be so far restricted as not to prevent these towns from receiving from it as much water as may be needed for their supply, in addition to the quantity of water which Crystal Lake will furnish.

It is not feasible from present information as to the amount of water which can be obtained from different places, to make a fair apportionment of the territory between Lynn and these towns; the Board therefore concludes that Lynn should be granted the right to take water from any portion of the valley of Saugus River, not already granted by the Legislature to some other town or water company; but that this grant should be subject to the restriction that the towns of Wakefield or Stoneham, or the company supplying them with water, may be authorized to take water from this valley at any point within the limits of the town of Wakefield, and to the extent required to furnish in connection with Crystal Lake, the present source of supply, a supply of water for these towns. In connection with this restriction it would, of course, be fair to provide that whenever these towns, or the company supplying them with water, take a supply from any source in the Saugus valley other than those already controlled by the Wakefield Water Company, they should be required to pay to the city of Lynn a fair

proportion of the amount already paid by said city for water or land damages, and if they should utilize to any extent works previously constructed by the city, they should pay a fair proportion of the cost of these works.

The Board thinks it proper that a further application should be made for its advice when you can define more specifically the sources from which it is proposed to take water, and have by preliminary surveys and estimates obtained the facts which are essential as a basis for a proper decision as to the relative merits of different sources. With this further application in view the Board will co-operate with you by causing analyses to be made from time to time of the water of the various proposed sources.

**MARLBOROUGH.** The water commissioners of Marlborough applied to the Board, April 28, for its advice relative to constructing a new storage reservoir upon Millham Brook in the west part of Marlborough, near the Northborough line, and as to the probable quality of the water of such proposed reservoir at the end of eight years. The Board replied as follows:—

Boston, July 8, 1893.

The State Board of Health has carefully considered your application, dated April 28, 1893, with regard to constructing at once the proposed storage reservoir on Millham Brook in the vicinity of your new pumping station. You state in your application that you will not need the proposed reservoir for eight years or so and that you wish for the advice of this Board as to the probability of obtaining good water from this proposed reservoir after being flowed fifteen feet deep for a period of eight years without removing any of the soil.

A careful examination of the experience with all artificial reservoirs in the State which have not had the soil removed from them and which in other respects are at all comparable with the proposed Marlborough reservoir shows that in some of these reservoirs the water was bad every summer, not only for eight years after they were first filled but for a much longer time. A typical instance of a reservoir of this kind is the Ludlow reservoir at Springfield which was used for sixteen years and then practically abandoned for a new source of supply. Other reservoirs somewhat similar in character, although they may have furnished bad water when first filled, soon began to improve, and at the end of five, eight or ten years furnished very much better water than at first. The chances as to whether the water will continue to be bad or will improve materially at the end of eight years seem to be about even.

The experience with reservoirs which have been thoroughly cleaned by the removal of all soil and vegetable matter from their bottom and sides, although somewhat limited, has been extremely favorable, and from our present knowledge we should expect much better results from a thoroughly cleaned reservoir soon after it is filled than from an uncleaned reservoir eight years after filling.

The Board recognizes that the element of cost is an important factor in determining what should be done, and as the Board has no accurate information upon this point it cannot now advise definitely as to what should be done in the matter of constructing the reservoir. It would advise, however, that a careful estimate of the cost of thoroughly cleaning the reservoir should be made and would urge the adoption of this method of construction if it is found to be practicable.

**MALDEN, MEDFORD AND MELROSE.** For many years these suburban places have used Spot Pond as a source of water supply, but owing to the rapid growth of these communities the pond was drawn to a much lower level at the end of 1892 than ever before. The city of Malden has for several years taken a supplementary supply from driven wells in the easterly portion of the city, but the other two places were at this time wholly dependent upon Spot Pond for water. On Feb. 9, 1893, the Board addressed the following communication to each of the water boards of Malden, Medford and Melrose, with reference to the present condition of Spot Pond, and its capacity for future supply: —

Boston, Feb. 9, 1893.

The State Board of Health has on several occasions since the spring of 1889 considered applications for advice with regard to additional water supplies for the three communities now using the water of Spot Pond, and in considering these questions the engineers of the Board have given much attention to the probable yield and capacity of this source.

Some figures with regard to the probable condition of this pond during the year 1893 have been made in connection with a recent application for advice from the city of Medford, and as they may be of interest at the present time they are sent to each of you. The data used are the area of the watershed as determined by a reconnaissance upon the ground, sketching the watershed upon the new State map and measuring from it, the storage capacity of the pond as determined from the best maps now in existence; also the records of the yield of the watershed of Sudbury River, which

has been carefully measured by the city of Boston for the past eighteen years.

It has been found by applying these data for many years in the past that the results agree well with the known facts, and they may therefore be looked upon as the best basis at present available for determining what may be expected in the future.

We are informed that the pond on the first day of February was 143.5 inches below high water mark, which, by the tables showing the storage capacity of the pond, would indicate a draught from high water mark down to this level of 731,000,000 gallons.

The following table shows for purposes of comparison the storage in the pond from high water mark down to the present and lower levels.

| Distance below High Water Mark, in Feet. | Storage in Gallons. |
|------------------------------------------|---------------------|
| 11 ft. 11½ in., . . . . .                | 731,000,000         |
| 15 ft., . . . . .                        | 837,000,000         |
| 20 ft., . . . . .                        | 962,000,000         |
| Bottom of pond, . . . . .                | 1,077,000,000       |

In making estimates as to what changes may be expected during the remaining months of 1893, the average consumption is assumed to be 600,000 gallons per day for each community, making a total of 1,800,000 gallons per day. It is found convenient to divide this period into two parts, including in the first one the months of February, March, April and May, during most or all of which the pond may be expected to rise, and in the second the remaining months, when under ordinary conditions it would lower, it is obvious that it is impossible to predict exactly what will happen, but it is fair to assume that the amount of water collected will not be greater than the maximum amount during the past eighteen years, nor will it be less than the minimum amount. It is more likely to be the average amount than any other quantity, but in as important a problem as the water supply of upwards of 50,000 people, provision should be made to avoid a water famine under the most unfavorable conditions which can exist.

It is found that on June first the deficiency of storage (meaning by this term the amount of water that would be required to fill the pond to high water mark) under maximum, average and minimum conditions of yield from February 1 to June 1, 1893, would be as follows : —

*Condition of Spot Pond on June 1, 1893.*

|                          | Deficiency of Storage. |
|--------------------------|------------------------|
| Maximum yield, . . . . . | 331,000,000 gallons.   |
| Average yield, . . . . . | 490,000,000 "          |
| Minimum yield, . . . . . | 677,000,000 "          |

For the period from June 1, 1893, to Jan. 1, 1894, it is obvious that regardless of the height of the pond on June 1 the amount of water going into the pond may be either the maximum, average or minimum, and the following tables show the deficiency in storage on Jan. 1, 1894, under all of these conditions.

(1) Assuming the deficiency in storage on June 1 to be 331,000,000 gallons, the deficiency on Jan. 1, 1894, will be as follows:—

|                          | Deficiency.          |
|--------------------------|----------------------|
| Maximum yield, . . . . . | 172,000,000 gallons. |
| Average yield, . . . . . | 535,000,000 "        |
| Minimum yield, . . . . . | 692,000,000 "        |

(2) Assuming the deficiency in storage on June 1 to be 490,000,000 gallons, the deficiency on Jan. 1, 1894, will be as follows:—

|                          | Deficiency.          |
|--------------------------|----------------------|
| Maximum yield, . . . . . | 319,000,000 gallons. |
| Average yield, . . . . . | 685,000,000 "        |
| Minimum yield, . . . . . | 841,000,000 "        |

(3) Assuming the deficiency in storage on June 1 to be 677,000,000 gallons, the deficiency on Jan. 1, 1894, will be as follows:—

|                          | Deficiency.          |
|--------------------------|----------------------|
| Maximum yield, . . . . . | 494,000,000 gallons. |
| Average yield, . . . . . | 863,000,000 "        |
| Minimum yield, . . . . . | 1,018,000,000 "      |

The most important conclusions to be drawn from the tables are, first, that with the average conditions from now until next January the pond will be at substantially the same level as at the same time this year; second, that if either one of the periods into which the year has been divided furnishes the average quantity of water and the other furnishes the minimum quantity, the water in the pond will be reduced to the 15-foot mark; and lastly, that if the yield for both of these periods should be a minimum the pond will be drawn practically to the bottom.

All of these estimates are based upon an average draught of 1,800,000 gallons daily from the pond, but it is doubtful if the draught can be kept as low as this without supplementary supplies

to furnish a portion of the water used. It is probable that a larger draught than the amount above given has had an influence in lowering the pond during the past year. The net loss of storage from the pond from Feb. 1, 1892, to Feb. 1, 1893, was 338,000,000 gallons. The same loss in the next twelve months would take all of the water out of the pond.

Not only should the conditions for the remainder of the present year be considered but the conditions which will exist subsequently until the time when a permanent supply is introduced should be considered, and it is therefore of the utmost importance that measures should be taken immediately, by providing supplementary sources or by making arrangements with some community which has water to spare, to get as much water into the pond as possible, or, what is the same thing, to take less water from the pond so as to have a larger supply in the pond to provide for the future contingencies, such as a rapidly growing population and supplementary supplies which may become unsuitable for domestic use. Every million gallons of water which can be added to the pond has a distinct value to the three communities now depending upon this source, which is much in excess of the mere cost of pumping the water, and it would be a benefit to all of the communities if a fixed price were made per million gallons of water, which should be charged to each community drawing more than a certain defined quantity and credited to any community taking from the pond less than this amount. This would offer an incentive for individual action on the part of those places which now have or can provide supplementary sources of supply and would not be unjust to any town that may be unable to obtain a supplementary source, as this town would only pay to the others what it would save in the cost of constructing and maintaining a pumping plant.

**MEDFORD.** The water commissioners of Medford applied to the Board, Jan. 4, 1893, for its advice relative to taking an additional water supply from wells west of Forest Street in Medford. The Board replied as follows:—

BOSTON, Feb. 2, 1893.

The State Board of Health has considered your application in regard to an additional water supply to be taken from driven wells in the flat open land west of Forest Street, where test wells have already been driven.

The Board has caused analyses to be made of samples of water taken from these wells and finds that it is a water which has at

some time been polluted, but which has been very thoroughly purified by its passage through the ground. The water as it now comes from the ground would be entirely satisfactory to the consumers as a drinking water, but it is much harder than the Spot Pond water and therefore would not be as good for washing purposes and for use in boilers. The hardness of the water, however, is not as great as that of several water supplies which are now in use in this State, and if the quality of the water remains as at present it would be satisfactory for the purposes of a public water supply. The situation of the test wells, however, is such that it seems probable that when a continuous draft is made upon the ground the water will be drawn in part from the territory south of the wells where there is a large population, and the water will become harder than it is at present, and it may be less perfectly purified; moreover, even if a large tract of land is purchased and controlled by the city for the protection of a water supply at this place the growth of the city will undoubtedly cause a material increase of population upon adjacent land, which contributes a portion of the water to supply the wells, and the character of the water may be further unfavorably affected in this way.

The Board would not therefore advise the construction of works for taking a permanent supply from this place, but in view of the necessity for supplementing the supply from Spot Pond, advises that this is a suitable source from which to obtain a temporary supply. The quantity of water to be obtained from this source is, with the present information, somewhat indefinite. It seems very doubtful if the source can be depended upon to furnish more than from 250,000 to 400,000 gallons per day continuously, though it is not impossible that during the wetter portions of the year a considerably larger quantity of water might be obtained.

In addition to the driven wells there is another source from which a temporary supply might be obtained, viz., the stream which flows just west of Forest Street, below where Elm Street joins it. Above this point there are very few houses or other sources of pollution upon the watershed, the area of which as measured from the State map is 0.58 square mile. An analysis of the water recently made shows that it is at the present time of suitable quality for water supply purposes, except that before being pumped it should be stored in a reservoir sufficiently large to permit the floating particles which are almost always found in brook waters to settle. During several months of an ordinary year the flow of this stream should be as high as 600,000 gallons per day, and during two months or more of such a year it should range from one to two million gallons per day. This source has the advantage that



it is very near the main pipe which leads to the town, and the water would have to be lifted to a less height to force it into the main. It is obvious, however, that in order to make it of value in the present emergency the works should be constructed at once so as to take advantage of the larger amount of water which flows in the spring of the year, as the amount of water to be obtained from this source in the summer would be comparatively small. The water would also be soft and suitable for laundry and boiler purposes, though not as palatable as that taken from the ground.

The choice of these two sources or whether both of them shall be utilized is a question which is left for your decision. The Board, however, considers it imperative that a supplementary supply or supplies should be provided at once by the communities using the water of Spot Pond in order to avoid a water famine during the next autumn and winter.

The results of certain computations with regard to the future condition of Spot Pond and a suggestion as to measures which should be taken to prevent the supply from being exhausted are embodied in another communication, a copy of which will be sent to you and to the water boards of Malden and Melrose. (See pages 28-31, preceding.)

**MELROSE.** The committee on additional water supply of Melrose applied to the State Board of Health, Dec. 5, 1892, for its advice as to the propriety of taking, either alone or in conjunction with Malden and Medford, the waters of Great Pond, in North Andover, together with Mosquito Brook and Boston Brook in the same town, as additional sources of water supply. The Board replied to this application as follows:—

Boston, Jan. 16, 1893.

In your application of Dec. 5, 1892, giving notice of your intention to provide an additional water supply for the town of Melrose and asking the advice of the Board in regard thereto, you make the following statement: "The plan proposed is, alone or in conjunction with the cities of Malden and Medford or either of them, to obtain authority from the Legislature to take and hold the waters of Great Pond in North Andover, and to acquire by purchase or otherwise the waters of Mosquito Brook and Boston Brook in said town of North Andover."

The State Board of Health has up to the present time received no applications relating to these sources from the cities of Malden or Medford and therefore considers only the first alternative, viz., a supply for Melrose alone.

Great Pond only has been investigated by the Board up to the present time, and it is found from this investigation and analyses of the water of the pond that the water is of satisfactory quality for all the purposes of a public water supply and that the quantity of water which the pond will furnish will be more than sufficient for the probable population of Melrose for the next thirty years.

Owing to the fact that the pond is situated wholly within the town of North Andover the Board is of opinion that this town has a primary right to so much of the water of the pond as is necessary to supply its inhabitants with water.

With regard to the appropriateness of this source for a water supply for the town of Melrose, the Board thinks it highly probable that a sufficient supply of good water for the town can be obtained at a less distance than sixteen miles and with less expense; and for this reason, and having regard for the interests of other communities much nearer Great Pond, which may in the future need its waters as a source of water supply, the Board advises the town to make examinations of nearer sources, and until such examinations are made is unable to advise that this is the most appropriate source of supply for the town of Melrose.

The Board will investigate the other sources mentioned in your application and advise you with regard to them as soon as practicable.

On February 3 the Board transmitted the following further communication upon the same subject to the committee on additional water supply of Melrose: —

Boston, Feb. 3, 1893.

The State Board of Health in its communication of Jan. 16, 1893, to your committee, relating to an additional supply of water for your town from Great Pond in North Andover, stated that further advice would be given with regard to the other sources mentioned in your application, viz., Mosquito and Boston brooks.

The application apparently relates to so much of these brooks as lies within the limits of the town of North Andover. The areas of the watersheds of these brooks above the points where they cross the town boundary, as measured from the topographical map of the State, are respectively 7.51 and 6.36 square miles, and their distances at these points in an air line from Melrose are  $14\frac{1}{2}$  and  $12\frac{1}{2}$  miles. These watersheds have been examined upon the map above mentioned, and upon the ground by one of the engineers of the Board, and they were not found to have any special characteristics which would make them as a whole particularly appropriate as sources of supply for Melrose or as desirable as other watersheds nearer the town.

It has been learned from statements made by a member of your committee and by your engineer, that it is proposed to utilize only so much of the upper end of these brooks as can be diverted by gravity through a ditch or canal along the side hill into Great Pond. In this case the area of watershed to be utilized is, according to the map above mentioned, in the neighborhood of three square miles instead of the total of about fourteen square miles above the town boundary. The three square miles are sparsely populated so that there is little danger that the water will be polluted, but there are swampy areas which give the water of the larger (Boston) brook a high color which would be objectionable if the water was to be taken directly into the pipes. If, however, this water is diverted as proposed into Great Pond its color will nearly disappear by long storage and by mingling with the nearly colorless water naturally in the pond.

The Board is of opinion that the town should not seek to acquire rights to the whole of Mosquito and Boston brooks within the town of North Andover, as the portions not available for diversion into Great Pond may be needed in connection with water supplies from the Ipswich Valley for other places in the eastern part of the State. If, however, the town of Melrose should be granted the right to take the waters of Great Pond it is appropriate that it should also be granted those portions of Mosquito and Boston brooks which can be diverted by gravity into it.

The water board of Melrose applied to the State Board of Health May 16, for its advice as to taking an additional water supply from wells to be driven in the meadow upon the north side of Ell Pond, and on July 5, the committee on additional water supply applied for advice with reference to taking water from other sources. The Board replied to these applications as follows:—

Boston, Aug. 10, 1893.

The State Board of Health received from the Melrose water board on May 16, 1893, an application for its advice relative to a proposed additional system of water supply to be taken from the ground on the north side of Ell Pond. On July 5 a second application was received from the committee on additional water supply for advice relative to taking a supply from Martin's Meadows, so-called, from Bennett's Pond or Meadows and from the Wakefield Water Company. On July 5 the last mentioned application was amended by adding Long Pond and its immediate vicinity to the sources before mentioned.

Before considering these sources in detail it will be well to refer in a general way to the capacity of your present source of supply, Spot Pond, and to the needs of your town.

Spot Pond during a year of average rainfall will supply to each of the communities taking water from it about 630,000 gallons of water per day; and, during a series of dry years, such as have occurred in the past, will furnish about 500,000 gallons per day to each community without falling to a lower level than it reached in February, 1893. With the pond at its present low level it cannot be depended upon to furnish even 500,000 gallons per day to each community if the next two or three years should be unusually dry. The consumption of water in Melrose by the meter records from September, 1892, to June, 1893, inclusive, averaged 565,000 gallons per day, which is 65,000 gallons in excess of the safe capacity of the pond for a series of dry years, even assuming it to have been filled in the spring, and still more in excess of its capacity in its present low condition. It is obvious, therefore, that to meet even the requirements of the present and the very near future it will be necessary to provide an additional source of supply or to decrease the consumption of water.

The consumption of water in Melrose at the present time is about 57 gallons per inhabitant, which is more than the amount used by most towns similarly situated. As instances of low consumption per inhabitant may be mentioned: Brockton, 25 gallons; Middleborough, 26 gallons; North Attleborough, 26 gallons, and Fall River, 26 gallons. On the other hand, Beverly uses 70 gallons, Braintree 62 gallons, and Brookline 80 gallons. During the period from September, 1892, to June, 1893, inclusive, Malden used 50 gallons and Medford 48 gallons per inhabitant.

It seems highly desirable that Melrose should take energetic measures to restrict waste, but in view of the fact that the present demands upon Spot Pond so largely exceed its capacity, and having regard to the present low state of the pond and the greater demand for water from year to year, due to the increasing population, the Board is of opinion that a further supply should be obtained without delay.

The great expense to which Melrose would be subjected if it should attempt to obtain by itself a permanent supply of water, which can only be had from a comparatively great distance, the fact that the Legislature has already directed that investigations be made with a view to obtaining a water supply for Boston and its suburbs, and the need of an immediate addition to the present supply, all lead to the conclusion that it is wise to obtain at a comparatively small cost a temporary supply which will meet the

requirements for the next five or six years. Should any of the sources mentioned by your committee be adopted, they should be considered merely as temporary sources which will have to be abandoned whenever the quality of the water becomes impaired by the growth of population upon the territory from which the supply is derived or by other causes, or whenever a more satisfactory and permanent water supply is introduced.

Of the sources mentioned by the committee it may be said that the water of Bennett's Pond, if taken directly from the pond, would not be of suitable quality on account of the large population near the upper portion of the brook which feeds it. With regard to a ground water from the vicinity of Bennett's Pond, no definite answer can be given because no investigations of the ground at this place have been made. It is not improbable that the quality of the water would be good, but, judging from the surface indications, this source could hardly be expected to furnish a sufficient quantity of water to make it a desirable one to adopt at the present time.

Long Pond by itself would not furnish a sufficient quantity of water to warrant taking an additional supply from it, and if a stream which flows near its westerly end should be diverted into it the quality of the water would not be satisfactory if taken directly from the pond. With regard to obtaining a ground water supply in this vicinity no investigations of the ground have been made, but, judging from surface appearances, the conditions are even less favorable than in the vicinity of Bennett's Pond.

The Wakefield Water Company now takes its supply from Crystal Lake, and the water is of suitable quality for the purposes of a public water supply. The quantity of water which this source will furnish in a series of dry years is but little, if any, in excess of the present requirements of the two towns now supplied by the Wakefield Water Company, and the only water which this company has to spare is the excess, during years of average or high rainfall, above the requirements of the two towns now supplied. The Board, therefore, does not advise the town of Melrose to depend upon the Wakefield Water Company for its additional supply. On the other hand, it is extremely important as a precaution against a water famine in the next few years that Spot Pond should be again filled, a result which can be accomplished if each of the communities now drawing water from the pond should obtain the greater part of its supply from some other source or sources; and it may therefore be desirable, if suitable arrangements can be made, to have the Wakefield Water Company supply as much water to Melrose as the capacity of its source will permit.

A sample of water collected from Whittier's wells in Martin's Meadows, so-called, on July 20 showed that the water obtained from the ground at this place was of satisfactory quality for the purposes of a public water supply, and from an examination of the premises it seems probable that this water will remain of suitable quality for use, at least until there is a further increase of population in this vicinity. The quantity of water which this source will furnish is apparently limited, and it is extremely doubtful if it alone will furnish a sufficient additional water supply for the town. Samples were also received from wells in the meadow above the one already mentioned, but the water from these wells was not of satisfactory quality to pump directly into the pipes.

The territory just north of Ell Pond has been tested in several places. The first test was made in January, 1893, by pumping from a line of driven wells very near the pond. This test lasted for fifteen days and the average quantity of water pumped is said to have been about 461,000 gallons per day. Three samples of water from these wells were sent to this Board for analysis. One was taken at the beginning of the test, another a week later, and the third at the end of the test. All of these samples were clear and colorless and free from odor, and, although they all showed, by the greater amount of mineral matter and hardness than the natural waters of this region, the effect of the population upon the territory from which the supply is derived, the analyses also show that the water had been very thoroughly purified by its passage through the ground.

Three additional samples taken from this vicinity in June and July, 1893, gave results which confirmed those above mentioned, the analyses showing that in every case the water had been completely purified, chemically, by its passage through the ground. The wells from which two of these last mentioned samples were taken were 175 feet from the pond, while the third sample was taken from one of the line of wells near the pond. A bacterial examination of a sample of water from one of these wells showed that the water was of good quality, bacterially.

There seems to be no doubt that the quantity of water which can be obtained from the ground in this vicinity is greater than from any of the other sources mentioned, and the principal question which arises with regard to this source is as to whether the water will remain of suitable quality for use after long-continued pumping. The principal source of danger is that the water of the pond, which is highly polluted, will find its way through the ground to the wells without being thoroughly purified by filtration. Ex-

perience has shown in some cases that water may filter from a pond to wells or to a filter-gallery and under some conditions be thoroughly purified by its passage through the ground, and yet under other conditions fail to be purified. It is impracticable to predict in the present case whether the water drawn from the ground will deteriorate in quality from this cause. Taking into account, however, the urgent needs of your town and the difficulty of obtaining a sufficient quantity of water from a better source, the Board would advise that this location be adopted as a source of supply, but with the understanding that the works are to be of a temporary character and that the water is to be analyzed frequently and its use discontinued if it should become impure. The wells should be located not less than 175 feet from the pond and further from it if practicable.

On Feb. 9, 1893, the Board sent a communication to the water boards of the three places drawing water from Spot Pond; and, after giving the results of estimates as to changes in the level of the pond which would be likely to occur under varying conditions of rainfall, the Board ended its communication with the following statement, to which it would again call attention:—

It is of the utmost importance . . . to get as much water into Spot Pond as possible, or, what is the same thing, to take less water from the pond so as to have a larger supply in the pond to provide for future contingencies, such as a growing population and supplementary supplies which may become unsuitable for domestic use. Every million of gallons of water which can be added to the pond has a distinct value to the three communities now depending upon this source, which is much in excess of the mere cost of pumping the water, and it would be a benefit to all of the communities if a fixed price were made per million gallons of water, which should be charged to each community drawing more than a certain defined quantity and credited to any community taking from the pond less than this amount. This would offer an incentive for individual action on the part of those places which now have or can provide supplementary sources of supply, and would not be unjust to any town that may be unable to obtain a supplementary source, as this town would only pay to the others what it would save in the cost of constructing and maintaining a pumping plant.

**MENDON.** The selectmen of Mendon applied to the Board, Dec. 27, 1893, for its advice relative to taking the water of Mendon Pond as a public water supply. The Board replied to this application as follows:—

BOSTON, Jan. 5, 1894.

The Board has already considered the question of the use of this pond as a source of water supply, in response to an application

made by the town of Uxbridge in 1892, and has caused analyses of the water to be made in October, 1892, and every month from May to November, 1893. During all of this time the water has been of satisfactory quality for all the purposes of a public water supply, and there seems to be no reason to doubt that if it is protected from pollution it will continue to be of satisfactory quality in the future.

Owing to its situation near the village of Mendon it is an appropriate source from which to take a supply of water for the village and any part of the town to which it may be desirable to extend the pipes.

The amount of water required for the supply of Mendon will not be large, and in the opinion of the Board the use of the pond as a source of water supply for Mendon should not prevent its use as a source of water supply by Uxbridge.

**METHUEN.** The water commissioners of Methuen applied to the Board, April 13, 1893, for advice as to obtaining a water supply for the town from driven wells near Sargent's Brook in the east part of the town. The Board replied as follows:—

Boston, May 19, 1893.

The State Board of Health has considered your application of April 13, 1893, relative to a proposed water supply for the town, to be taken from driven wells near Sargent's Brook, and has caused examinations of the premises and analyses of the water to be made.

The analysis of a sample of water sent in from one of the flowing wells showed the water to be very pure and soft, and in all respects an excellent water for the purposes of a public water supply. After pumping for nearly six days, however, from these wells another sample was collected, and the character of the water was found to have undergone a decided change and to be much less satisfactory. Should this deterioration continue with steady pumping, as has been the case in some other places in the State, the water would become objectionable.

The watershed above the point where the wells are located was examined and its area determined approximately by sketching its outlines upon the topographical map of the State, and subsequently measuring it. This area was found to be so small that the total amount of water flowing from it, through the brook and through the ground, in a dry year would not be in excess of the requirements of a water supply for Methuen, having due regard to future



needs. It was obvious from an examination of the watershed that much of the water would flow off through the brook, particularly in the spring of the year, so that the supply to be obtained from the ground would be much less than the total flow from the watershed, and probably not enough during the dryer portions of a dry year to supply the town as soon as water is generally introduced.

On July 5 the water commissioners of Methuen again applied to the Board for its advice upon the question of taking a water supply for the town from wells driven near the Spicket River at the junction of the brook leading from Harris Pond. The Board replied to this application as follows : —

Boston, July 25, 1893.

In response to your application of July 5, 1893, with regard to a proposed water supply for the town of Methuen, to be taken from driven wells located near the Spicket River near the point where it is joined by the brook leading from Harris Pond, the Board has caused an examination of the locality and an analysis of a sample of water sent in by you from one of these wells to be made. The analysis showed that the water sent in was of excellent quality for the purposes of a public water supply. Judging from the tests made under your direction, and from an examination of the territory in the vicinity of the test wells, it is probable that a sufficient supply for the town for at least a few years may be obtained from the ground near where the tests have been made, and this location has the great advantage that it is well situated for taking a supplementary supply of water from Harris Pond whenever the quantity of water which can be obtained from the ground proves insufficient.

NEWBURYPORT. In the report of the State Board of Health to the Legislature, dated Jan. 10, 1893 (Senate Document 4, 1893), it was stated that the water of the Merrimack River had been furnished directly to the citizens of Newburyport by the Newburyport Water Company, and that a letter had been sent to the Newburyport Water Company, November 3, informing them that the water of the Merrimack River was unfit for domestic use, and advising them to obtain a further supply of pure water without delay. This advice having been disregarded by the company, an epidemic of typhoid fever took place in January and February, 1893, among the citizens of Newburyport. The Board then ad-

addressed the following communication to the mayor of Newburyport : —

BOSTON, March 3, 1893.

*To the Mayor of Newburyport.*

DEAR SIR : — On the 3d of November, 1892, having learned that the Newburyport Water Company had at times pumped the water of the Merrimack River and distributed it to the citizens of Newburyport, the State Board of Health addressed the following letter to the company : —

The Board, as a result of extended examinations of the effect of using the Merrimack River water at Lowell and Lawrence, reached the conclusion that it is to this cause that the excessive mortality from typhoid fever in these cities, as well as the very severe epidemic of this disease in the winter of 1890-91, may be ascribed. The condition of this river at Newburyport is worse than at either Lowell or Lawrence, owing to the added sewage of the cities of Lawrence and Haverhill, and the town of Amesbury.

In view of this condition of affairs, the Board is of opinion that the Newburyport Water Company should obtain a further supply of pure water without delay, so that there will be no further occasion for pumping water directly from the river.

In the Twenty-second Annual Report of this Board, page 527, it was shown that the introduction of a pure water supply into Newburyport in 1881 was followed by a reduction in the death-rate from typhoid fever of more than one-half.

It now appears from an investigation recently made by this Board that the frequent pumping of a considerable quantity of the water of the river has been followed very closely by an epidemic of typhoid fever among your citizens. This epidemic, in the opinion of the Board, is due to the use of the river water, following an increased prevalence at places higher up the stream.

These results emphasize still more strongly the opinion of the Board expressed in its letter of November last to the Newburyport Water Company, relative to the necessity of "obtaining a further supply of pure water without delay," and in the opinion of the Board such a supply cannot be obtained by developing the present spring-water sources.

The mayor of Newburyport applied to the State Board of Health, April 13, 1893, for advice as to taking the water of Artichoke River, in that city and the town of West Newbury, as a source of water supply for the city, such water to be purified either by artificial or natural filtration through sand. The Board replied as follows : —

BOSTON, April 24, 1893.

An examination of this source shows that by the construction of a storage reservoir as proposed it can be made to furnish a sufficient quantity of water for the city of Newburyport for a long time in the future. With regard to the quality of the water the examinations thus far made show it to be a water of fair quality, but it would not probably be satisfactory for drinking purposes without filtration. The Board is of opinion that it will be feasible to so filter this water that in connection with the existing works, or independent of them, an ample and satisfactory supply for the city can be obtained.

The Board makes a reply at this time instead of waiting for your further surveys and investigations because it understands that its advice is desired now in connection with pending legislation, and will advise you further with regard to the filtration of the water when the results of the further surveys and investigations are presented.

**NORTH ANDOVER.** The committee on water supply of the town of North Andover applied to the Board, Dec. 13, 1892, for advice relative to taking the water of Great Pond in that town for a public water supply. The Board replied to this application as follows:—

BOSTON, Jan. 16, 1892.

The State Board of Health has considered your application dated Dec. 14, 1892, with regard to a proposed water supply for the town of North Andover, to be taken from Great Pond within said town.

The Board has caused examinations of the pond and analyses of its water to be made, and finds that the water is of satisfactory quality for all the purposes of a public water supply and that the quantity of water which the pond will furnish is many times in excess of the quantity which will be required for the supply of the town.

The Board is therefore of opinion that Great Pond in North Andover is an appropriate source from which to take a water supply for the town.

**PEABODY.** The Water Board of the town of Peabody sent the following communication to the State Board of Health, April 18, 1893, relative to the threatened pollution of their water supply by drainage from new settlements upon the immediate watersheds of the two ponds used as water supplies:—

PEABODY, MASS., April 18, 1893.

*State Board of Health, Boston, Mass.*

GENTLEMEN:—By a vote of the water board, I am instructed to respectfully represent to you a matter of vital importance to the town of Peabody. Parties have purchased the land north of Spring and Brown's ponds, the water supply of the town, and have cut it up into house lots, and as the land on both places slopes toward the ponds, the matter of polluting the water in the ponds is deemed of such great importance to the town that the Water Board would respectfully request that a member of the State Board of Health come here some time to look over the premises, and suggest some remedy, if possible.

Yours respectfully,

HENRY BAETJE,

*Clerk, Water Board.*

In compliance with this request of the water board of Peabody, the secretary of the State Board visited the sources of water supply of the town, in company with the water board, and afterward addressed a letter to them, by instructions of the State Board of Health, giving such information as to existing statutes as would be serviceable for the protection of their water supplies from pollution.

ROCKPORT. An application was received from H. N. Woods and others, and the selectmen of Rockport, Jan. 4, 1893, asking the advice of the Board relative to the taking of a public water supply from Cape Pond, or Mill Pond Brook in that town, and in the event of these sources proving unsuitable, from the Gloucester Water Company. The Board replied as follows:—

BOSTON, Feb. 18, 1893.

An application with regard to Cape Pond as a source of water supply for Rockport was made to the Board on March 18, 1890, and the reply of the Board dated March 26, 1890, was as follows:—

The Board has caused samples of water to be taken from the pond and has had them submitted to chemical and microscopical examination. The water at the present time is not found by either examination to be of satisfactory quality. It contained an unusually large number of organisms, and is therefore specially liable to bad tastes and odors, such as have affected many water supplies in the State. It is also shown by analysis to contain a large amount of ammonia, which indicates the presence of decaying matter. It is not feasible to tell whether the water

at the present time is better or worse than at other seasons of the year; but, as a rule, the quality of the water of ponds is worse in the summer.

In view of this unsatisfactory condition of the water, the Board cannot at the present time advise that this pond will be a desirable source of supply for the town of Rockport, unless the water supplied is first efficiently filtered. If it should be found by subsequent examinations that the water of this pond is better at other seasons of the year than at the present time, the Board might have occasion to modify the advice above given.

Since the above date four samples of water were collected from the pond, in August and October, 1892, which showed by the chemical examination the presence of more organic matter than is desirable in water, and by the microscopical examination the presence of a large variety and number of organisms. On the whole, however, these samples indicated that the water was of better quality than in 1890. A sample collected in February, 1893, shows still less organic matter and fewer organisms, so that the water as represented by the last sample may be considered as of satisfactory quality for water supply purposes. Notwithstanding these changes for the better in the organic matters in the water, the mineral contents show that there is an increasing pollution of the pond by the waste matters which come from the glue factory upon the watershed, and there is little doubt that if these waste matters continue to affect the pond the water will be specially liable to bad tastes and odors caused by too great an amount of organic matter and too many organisms in the water, whereas if the waste matters were removed from the watershed so that they could not affect the pond by direct flow into it, or by filtration through the ground, the quality of the water would probably improve to a considerable extent in two or three years, and after a longer term of years the water in the pond would resume its natural character.

The Board is therefore of opinion that this pond should not be used for water supply purposes unless the pollution of its water ceases, but that if the pollution is stopped the water will become of satisfactory quality for the supply of the town.

With regard to the quantity of water which this pond will furnish, it will probably supply sufficient water for the present population of the town but not enough to provide for a growth of population, and in designing works for taking a supply it would be well to take into account the need of an additional supply, which can probably be obtained from the streams which come from a northerly direction into the brook which flows from Cape Pond, or possibly from wells in the low land through which this brook flows.

Millpond Brook, so-called, is naturally inferior to Cape Pond as a source of water supply for Rockport, and it is very doubtful if it could be made to furnish a sufficient quantity of water for even the present population.

**SALEM.** The water commissioners of Salem applied to the State Board of Health, Feb. 17, 1893, for advice relative to increasing the present water supply of the city by taking water from Beaver and Norwood's ponds and Longham Meadow, certain regions which are tributary to Miles River, and conveying the same by a canal to Wenham Lake, the present source of supply. The Board replied as follows:—

BOSTON, April 4, 1893.

Investigations of the present source of water supply for Salem and Beverly (Wenham Lake) show that the safe capacity of this source has been exceeded to a considerable extent, and that a new supply should be provided by the end of 1893 if not before. The most economical source from which to obtain such a supply is that referred to in the application, as these brooks, at the point where their waters can be diverted, are only about half a mile from Wenham Lake, and so few feet below its level that the water can be diverted into the lake without pumping by raising the water of the brooks by means of a low dam.

Since your application was made two sets of analyses of water from these brooks have been made. The first one was made on March 1st, when there was a large amount of snow on the ground and very little water running in the streams. At this time the water was very dark-colored and had a disagreeable odor and taste, so that it would be wholly unsatisfactory as a source of water supply if taken directly into the pipes. The next sample was taken on March 15th when a large part of the snow had melted and a great amount of water was flowing in the streams. The water of the Longham Meadow Brook at this time, although somewhat turbid, owing to the presence of earthy matter, had only one-third as much color as on March 1st and was in other respects a much better water. The water of the brook flowing from Norwood's Pond also showed a very decided improvement, but not as much as in the other case, as the water from the melting snow had not had time to crowd out all the water previously in the ponds on this stream.

If the water of these streams was turned into Wenham Lake near its outlet, as is now proposed, it would mingle with the water

of the lake, making a mixture very much better than the water coming from the brooks, and, in addition, the water standing for so long a time before being used as it would in so large a body of water as Wenham Lake would improve to a very considerable extent by bleaching and sedimentation. In order, however, to maintain as nearly as possible the present standard of Wenham Lake water, it is highly desirable that only so much water as may be necessary should be turned into the lake from these brooks, and that it should be turned in at the season of the year when the water in the brooks is in its best condition.

The stream at the proposed point of diversion is as before indicated lower than the lake; and, in order to divert the water into the lake by gravity, it is necessary to raise the water in the stream by means of a dam. The question has therefore been raised as to whether it is not best to make a dam high enough to form a large reservoir which will furnish a valuable addition to the present storage capacity. The surveys of this reservoir have not yet been completed and it is not feasible to tell from observation alone what its character will be. It seems probable, however, that unless a very large amount of money is spent in its preparation the water would deteriorate to a very considerable extent by standing in it and that, at the present time, it would be better to construct a dam having only sufficient height to turn the water into the lake. Even a low dam at this place will flow the water back for a long distance up the valley of the Longham Meadow Brook, and if the reservoir is to be kept filled at all seasons of the year it should be prepared to receive this water by the removal of all soil and vegetable matter and the deepening or filling of the shallower portions. If, however, the reservoir should be filled to divert water into the lake only in the winter and spring it is not improbable that satisfactory results may be obtained by a less expensive preparation.

It may be feasible by ditching or otherwise draining the swampy lands or ponds upon the watersheds of these brooks to greatly improve the quality of the water flowing in them, and the Board would advise that this question of the improvement of these sources should be investigated and that any act authorizing the taking of these sources should contain such provisions as will permit this work to be done.

The total area drained by these streams is much larger than that now supplying Wenham Lake, and, in connection with Wenham Lake and its watershed, should furnish a supply of water for Salem and Beverly for a long time in the future without building a large storage reservoir, provided the water is economically used.

The amount of water now consumed by Salem and Beverly, as given in the annual reports of the water boards, is unusually large for such communities, and the Board would therefore advise that measures should be taken to restrict the waste of water ; not, however, with the expectation that the need of an additional supply can be avoided, but rather with a view to maintaining as nearly as possible the present standard of quality of the water supply by adding to it as little water from the new sources as possible, and also with a view to making the proposed addition provide for as far in the future as possible.

Taking everything into consideration the Board is of opinion that the two streams mentioned in your application, including with them a small portion of the main stream below their confluence, are the most appropriate sources for obtaining an additional water supply for Salem and Beverly.

The Board has given its present views in a general way as to the best method of obtaining such a supply from these sources, but will advise you more in detail when you have made a further study of the subject and can present more definite plans.

**SAUNDERSVILLE.** The treasurer of the Saunders Cotton Mills in Grafton, applied to the Board, October 18, for advice as to supplying the mill and houses in its neighborhood with water from springs upon a hill near the village. The Board replied as follows : —

Boston, Nov. 2, 1893.

The Board has caused an analysis of the water from one of these springs, and an examination of the territory from which they derive their supply, to be made. The water is very soft and of suitable quality for all the purposes of a water supply, and the covering which you propose to put on the reservoir will tend to preserve the good quality of the water when it is stored. In order to maintain the purity of the spring water, care should be taken to exclude all surface water.

Judging from the quantity of water discharging from the springs at the time the examination was made by the engineer of the Board, and from statements made to him as to the permanence of these springs, it seems probable that they will furnish enough water to make them a valuable source of supply for the mill and the houses in its vicinity.

In addition to the sample of water from the spring, another sample, taken from a well which now supplies water to the mill, was analyzed. This analysis shows that a portion of the water



coming to this well has at some time been polluted and afterwards thoroughly purified by its passage through the ground to the well. While there is no reason to think that this water, in its present condition, would be injurious to the health of those drinking it, it is a much less desirable source of domestic supply than the springs on the hill.

**SCITUATE.** M. R. Simmons and others, and the selectmen of Scituate applied to the Board, Dec. 10, 1892, for its advice relative to taking water for supplying the village of Scituate Harbor, from the valley of Satuit Brook in that village. The Board replied as follows:—

Boston, Feb. 21, 1893.

The general outlook for obtaining a sufficient quantity of water for present and future requirements from the ground where the test wells are located is favorable both as regards the area and topography of the watershed from which the supply would come, and because the test wells show the presence of a layer of porous sand from which water can be drawn. The amount of water to be obtained, however, will depend upon the extent of this porous layer, and the freedom with which water can be pumped from it, and it will be advisable to make some further tests to determine these features before constructing works.

The sample of water collected from a flowing test well is of good quality, and it seems probable that the quality of the water will remain good when a supply is pumped from the ground. In some cases, however, the quality of water from wells in a meadow deteriorates when pumped, and it would be well to have additional samples analyzed when a pumping test is made.

**SHARON.** The board of health of Sharon, under instructions from the town, requested the advice of the State Board of Health, Aug. 28, 1893, with reference to the possible pollution of the public water supply of the town, under existing conditions, and as to the best practicable method of assuring its purity in the future. The Board replied as follows:—

Boston, Oct. 6, 1893.

When any part of the territory from which a well derives its supply is populated and the waste waters of this population are discharged into the ground, these waters percolate downwards until they reach the level of the water in the ground, and then, mingling with the natural ground water, filter slowly toward the well. In

such a case the dissolved mineral matters (for instance, common salt, and the salts of lime and magnesia which make water hard) are not removed by the filtration; but the organic matters may be decomposed and wholly transformed into harmless mineral matters by filtering through the ground for a sufficient distance.

The State Board of Health has caused chemical analyses of water from the well of the Sharon Water Company to be made from time to time since June, 1887, the last analysis being made in September, 1893. These analyses show the presence in the water of some of the mineral matters due to the population upon the territory from which water filters toward the well, and the water, although not hard, is harder than it would be if it were not for the population upon this territory. They also show that such polluted waters as have mingled with the ground water have been very thoroughly purified at all times, and the recent analysis fails to reveal even a trace of organic matter. It may therefore be said that the water is very pure at the present time.

There is scarcely a doubt that the waste waters discharged into the ground from the more distant points will continue to be thoroughly purified before reaching the well, and the effect of an increase in population at these points would be to increase the hardness of the water rather than to render it injurious to health. There is a greater probability that the water may at some time be polluted by the wastes which enter the ground at nearer points, say within a distance of from 600 to 800 feet from the well; and it is highly desirable that within this distance this method of disposing of the waste matters shall cease.

If there should be a very large increase of population upon the more distant territory which contributes water to the well, it may be necessary at some time in the future to provide a water-tight system of sewers to carry off the liquid wastes, or to obtain the water supply from some new location.

**SOUTHBRIDGE.** The Southbridge Water Supply Company applied to the Board for its advice, Sept. 5, 1893, relative to the question of increasing the public water supply by building a new dam about one mile south of the present upper reservoir, and as to the improvement of the present supply and storage capacity. The Board replied as follows:—

Boston, Oct. 13, 1893.

We are informed by your engineer that this new reservoir will have sufficient capacity to store 50,000,000 gallons; but, as you

have not made surveys of the watershed, to determine its area, it is not feasible to advise you other than in a general way as to the quantity of water which this source will furnish.

It is also the case that when this source was inspected by an engineer of the Board, there was no water running in the stream at the site of the proposed dam, so that it was not possible to get a sample of water for analysis. The inspection of the watershed by this engineer, however, indicated that the water flowing from it was naturally of good quality, and that more water could probably be obtained from this source than from the present works.

The water would probably deteriorate somewhat by storage in this large reservoir, in any case; but much more if the reservoir is not cleaned, than if it is thoroughly cleaned by the removal of all soil and vegetable matter.

In answer to your second question asking the advice of the Board with regard to the improvement of the present supply, it may be said that it does not appear feasible to increase the storage in a satisfactory manner nor to materially increase the quantity in any other way. It should also be borne in mind that if you adopt the new source and construct the large proposed reservoir upon it, it will be feasible to operate the two systems together so as to utilize some of the water which now flows to waste over the lower dam of your present works in the spring of the year. For example, when enough additional water takers have been connected with the works to use all of the water which the present and proposed works will furnish in a dry time, it may frequently happen that the lower reservoir will be overflowing, while the proposed reservoir, owing to its large size, will not be full. At such times it will be feasible to supply the greater part of the town from the old source, thereby permitting less of the water to flow to waste, and reserving the water of the proposed reservoir for use during the drier portions of the year.

With regard to the improvement of the quality of the present supply, the measures suggested are the removal of any organic matter which may be in the reservoir, and the ditching of any lands of a swampy nature over or through which the streams flow to the reservoirs, so as to prevent, as far as possible, the water from coming into contact with organic matter or standing upon the surface of these lands.

It is improbable that your present and proposed works together will furnish as much water as ought to be provided for a large and growing town like Southbridge, and the Board would therefore advise that you have thorough investigations made with a view to determining the best source for the permanent supply of the town.

Should you find a source which will furnish an adequate supply of good water it would probably be a measure of true economy to adopt it at once, rather than to spend money upon a source which in a very few years is likely to prove inadequate, if the pipe system of the town should be extended to any considerable extent. Should your investigations of the larger sources lead you to conclude that it is desirable to adopt one of them, the Board will advise you further in this matter when you shall have submitted the results of your investigations.

The Southbridge Water Supply Company submitted a second application, Oct. 14, 1893, stating that they had made the investigations of the larger sources of supply suggested by the Board, to which the Board replied as follows : —

Boston, Dec. 8, 1893.

The State Board of Health received from you on Oct. 16, 1893, a second application with regard to increasing the water supply of the town of Southbridge, and at a subsequent date received a plan of a storage reservoir which it is proposed to build on Hatchet Brook.

The Board has caused an examination of the premises by one of its engineers, and analyses of the water from Hatchet Brook at the site of the proposed dam, from one of its principal tributaries and from Hatchet Pond to be made. The examination and analyses showed the water to be free from pollution, and that it is soft and of suitable quality for all the purposes of a public water supply. In order to maintain the purity of the water when it is stored, the reservoir should be prepared for use by the removal of all soil and vegetable matter from its bottom and sides.

With regard to the quantity of water, this source with a storage reservoir constructed in accordance with the plan submitted should furnish in the driest year a sufficient quantity of water for a population considerably in excess of the present population of Southbridge, and it is capable of still further development.

The Board therefore concludes that Hatchet Brook at the proposed point of taking is a suitable source of water supply for the town of Southbridge.

**SOUTH DEERFIELD.** The South Deerfield Water Company applied to the Board, Nov. 17, 1893, for its advice as to the propriety of taking Clapp's Trout Brook as a water supply for South Deerfield. The Board replied as follows : —

BOSTON, Dec. 14, 1893.

Clapp's Trout Brook is a small stream which flows down the easterly slope of the range of hills situated about two miles west of the village of South Deerfield. North and south from this brook there are two much larger streams which flow from the same range of hills, namely, Roaring Brook, in the town of Whately, and Mill River, of which Clapp's Trout Brook is a branch, in the town of Conway. Examinations of all of these sources, by an engineer of the Board, and analyses of the water have been made. The analyses show in all cases a water of excellent quality, slightly harder than most of the drinking waters of the State, but yet not hard enough to be objectionable on this account. There was little difference in the hardness of the samples from Clapp's Trout Brook and Roaring Brook, though the latter had a slight advantage in this respect. The sample of water from Mill River was considerably harder than either of the others.

The quantity of water which Clapp's Trout Brook will furnish in a very dry year cannot be accurately estimated from the information now in the possession of the Board. It is obvious, however, from an examination of the territory and of the State map, that the area drained by the brook is quite small, and it is doubtful if this source will furnish enough water in a dry year to supply the village of South Deerfield, after the water has been generally introduced.

Roaring Brook will certainly furnish all the water required, and Mill River, above the point where its water can be diverted to the village by gravity, will probably furnish a sufficient quantity of water. The latter source has the objection, however, that it is much further from the village.

With its present information the Board does not advise the adoption of Clapp's Trout Brook as a source of supply for the village; but it might modify its views if surveys should show that the watershed has a larger area than is now supposed, or should show that it is feasible to build a reservoir or reservoirs upon it, in which to store a sufficient amount of water to tide over dry periods. There seems to be no doubt that a satisfactory supply of water can be obtained from Roaring Brook.

The Board advises you to have further investigations made to determine whether Clapp's Trout Brook will furnish a sufficient supply of water, and, if it will not, to determine whether it is not feasible to obtain a supply from Roaring Brook. When you have further information to present the Board will advise you further in this matter.

STOUGHTON. The water commissioners of Stoughton sent a communication to the Board, Sept. 7, 1893, stating that works recently completed for supplying water to the town had proved wholly inadequate, and that the commissioners desired the advice of the Board relative to taking some new source or devising some method of obtaining a larger supply from the present plant. The Board replied as follows : —

Boston, Oct. 13, 1893.

In April of last year the Board received from you an application for its advice with regard to a new water supply for the town of Stoughton, in which you designated the region near Knowles Brook and Muddy Pond for the consideration of the Board. In the reply to this application, dated May 5, 1892, the Board, in giving the relative capacities of the two sources mentioned, estimated that the Muddy Pond source would furnish a supply for nearly if not quite double the present population of Stoughton, but qualified the statement by saying that “these estimates are based upon the assumption that loose gravelly ground can be found in both of these locations to a depth of from thirty to forty feet, and may require modification if examinations of the ground, which should be made before any final decision is reached, show that this is not the case.” The reply concluded with the following statement : — “The Board is therefore of the opinion that the most appropriate source from which to obtain a water supply for Stoughton is the ground in the vicinity of Muddy Pond, provided further examinations show that porous material at this place is of sufficient depth and extent.”

The new well has been located one-quarter of a mile or more below Muddy Pond, and, owing to its location, the slight depth to which the water in it can be drawn down with the present arrangements for taking water, and probably, also, to the somewhat impervious nature of the material in which the well was sunk, the quantity of water which it will supply is small. Under the present conditions it is obviously desirable to bring additional water to the works already constructed, if it can be done at a reasonable cost, rather than to make any radical changes in the works.

Near the upper end of Muddy Pond, as you well know, there are many large springs outcropping at the base of the high land which partially surrounds the pond. There is no reason to doubt that this spring water, as it comes from the ground, is of excellent quality ; and if a sufficient quantity of such water can be turned into the present pump well it would furnish a most excellent water supply for the town.

The outflow from Muddy Pond represents quite correctly the total volume of water furnished by the springs above referred to, and by such other springs as may be located in the bottom of the pond or in the swamp surrounding it. A measurement of the outflow from the pond made on April 26, 1892, showed the volume to be 1,410,000 gallons per twenty-four hours, and another measurement made on Sept. 11, 1893, showed that the flow was then fully 1,000,000 gallons per twenty-four hours. The comparatively small difference between the measurement made in the spring of the year, when the flow would naturally be greatest, and in the autumn, when the flow would naturally be low, shows that the yield of these springs is remarkably constant.

The smaller quantity of water is about four times as large as the average daily quantity required to supply the present population of Stoughton. It would not be fair, however, to reckon that this source would supply four times the present population of Stoughton, because, during dryer seasons, the springs are likely to be lower than at the present time; and provision is also to be made for the maximum rate of consumption in summer, rather than the average rate throughout the year. There now appears to be an abundant supply of spring water for a much larger population than that of Stoughton entering the pond from the springs, which can be conveyed by an intercepting pipe to the present works. The Board would therefore advise that provision should be made for intercepting the spring water which now finds its way into the pond before the water has been exposed to the light or come in contact with the vegetable matter in the swamp surrounding the pond, and for conveying the intercepted water to the present works.

While the main feature of works for carrying out the advice above given is a pipe tapping the springs and extending from them to the present works, there are many precautions which should be taken to insure success. The attempt should be made to collect *all* of the spring water which enters the pond, and for this reason the intercepting pipe should be everywhere at a lower level than the water in the pond. In order to intercept the water of the springs, the pipe through that portion of its length where the springs are located should be laid with open joints and surrounded and covered with a liberal amount of screened gravel. Smaller branch pipes may also be required at those points where the spring water outcrops in the greatest quantity.

The pipe laid from the territory where the water would be collected to the present works should be of large size, say eighteen inches in diameter, so that it will convey the water to the vicinity of

the present collecting well with very little loss of pressure due to friction ; and this pipe should communicate with the 12-inch pipe leading from the collecting well to the pump well. The 12-inch pipe should have a check valve on it above the point where the new pipe connects with it to prevent the water from backing up into the collecting well and being lost by leakage into the ground about this well. It will also be necessary to make the joints of the new pipe water-tight wherever the pressure of the water in this pipe will cause it to leak out through the joints.

In order to concentrate the flow of the whole twenty-four hours so that it can be pumped in the daytime it will be necessary to stop the flow of water from the pipe at night and permit it to back up in the gravel surrounding and in the vicinity of the open-jointed pipe.

The Board would urge upon you the advisability of having this new work done in a liberal and thorough manner so as to insure the collection of all of the spring water without deterioration of quality. The total cost of doing this work thoroughly would be but a very small percentage of the whole cost of the system of water supply for the town, and yet it represents the most important part of the whole work, namely the collection of an ample supply of excellent water.

UXBRIDGE. The committee on additional water supply for the town of Uxbridge applied to the Board, March 18, 1893, for its advice as to the comparative merits of Seagrave Brook and Cold Spring Brook in Uxbridge, and of Mendon Pond in Mendon, as sources of water supply for Uxbridge. The Board replied as follows :—

Boston, April 4, 1893.

The Seagrave Brook drains so small a territory that, even if extensive storage reservoirs should be constructed upon it, it would not probably furnish a sufficient supply for even the present population of Uxbridge after water was generally introduced in all of the villages ; and this source has no advantage in regard either to the quality of the water or to economy of construction which should lead to its introduction as a temporary source of supply.

Cold Spring Brook, at the proposed point of taking at the old sawmill site, below the Douglas Road, drains so large a territory that its natural flow, supplemented by a comparatively small amount of storage to tide over the dryer portions of the year, would be sufficient to supply Uxbridge with water for many years ; and should the supply at any time prove insufficient, the capacity



of the source may be increased by providing additional storage capacity. A sample of water was collected from the brook near the proposed point of taking on March 25, 1893, which showed the water to be a fairly satisfactory one for water supply purposes. The sample was collected, however, at a time when the streams were swollen by the water from melting snow, and the analysis may, therefore, differ considerably from the analysis of the water at other seasons of the year.

The principal objection to this source is its low level, which makes it necessary to pump the water and consequently increases both the first cost of the works and the annual cost of maintenance. When compared with Mendon Pond it seems probable that the first cost of works from Cold Spring Brook will be as large on account of the cost of a pumping station, offsetting the additional length of pipe required to take water from Mendon Pond; and Cold Spring Brook has the disadvantage of the continued expense of maintaining a pumping station, while the water will flow from Mendon Pond by gravity.

It was not feasible at the time this examination was made to obtain a representative sample of water from Mendon Pond, as the ice was not strong enough to bear the weight of a person, and the water near the edges was affected by the water entering the pond from the melting snow.

To sum up the comparative merits of the different sources, the Board is of opinion that the Seagrave Brook source has no advantage either in regard to quantity, quality or cost. A final opinion in regard to the relative merits of Cold Spring Brook and Mendon Pond in regard to the quality of the water cannot be given at the present time on account of the fact that the few examinations made may not be representative of the quality of the water at all seasons of the year, but it seems probable that Mendon Pond can be made to furnish the better water. The cost of a water supply from Mendon Pond will be very much less than from Cold Spring Brook when the cost of maintaining a pumping station is taken into account.

● **WAKEFIELD.** The Wakefield Water Company requested the advice of the Board, Feb. 23, 1893, relative to introducing "an additional water supply" for Wakefield and Stoneham, from "filtering galleries, wells, or basins upon the banks of that portion of the Saugus River lying within the limits of the town of Wakefield, and above the milldam near the Montrose station of the Salem branch of the Boston & Maine Railroad." The Board replied as follows:—

Boston, April 14, 1893.

From such data as are now available the Board believes that the capacity of the present source (Crystal Lake) in a series of dry years has been practically reached, so that there is need of an additional water supply for these towns. It has already expressed and still holds the opinion that the water of Quannapowitt Lake, one of the sources named in your original act of incorporation, is now unfit for the purposes of a domestic water supply. This opinion as to the quality of Quannapowitt Lake water applies to taking water directly from the lake, but if the water was taken after it had been thoroughly purified by filtering for a long distance through the ground or by any other thorough method of filtration it might be used. It seems probable, however, that the most satisfactory additional supply for the towns of Wakefield and Stoneham can be obtained by taking water from the ground at some point above the dam at Montrose, as indicated in your application.

In the absence of any investigations to determine either the quality or quantity of water which may be obtained from different portions of this territory, it is not feasible to give any specific advice in these respects at the present time.

The city of Lynn, which now takes its supply from sources within the Saugus valley, is in urgent need of an additional supply of water and desires to take it from this valley, and the valley is also nearer other communities in need of additional water supplies than any other large sources not now in use or so much polluted as to be unfit for water supply purposes. While, therefore, the Board believes that the towns of Wakefield and Stoneham should have the first right to a water supply from the portion of the valley within the limits of the town of Wakefield it does not believe that they should control more territory than is necessary for this purpose.

In view of the impracticability of making any fair apportionment of territory at the present time, the Board in its reply to the application of the city of Lynn relative to an additional water supply, concluded that Lynn should be granted the right to take water from any portion of the valley of the Saugus River not already granted by the Legislature to some other town or water company, but that this grant should be subject to the restriction that the towns of Wakefield or Stoneham, or the company supplying them with water, may be authorized to take water from this valley at any point within the limits of the town of Wakefield, and to the extent required to furnish in connection with Crystal Lake, the present source of supply, a supply of water for these towns; provisions to be made in connection with any grant of this character, however, that whenever these towns, or the company supplying

them with water, should take a supply from any source in the Saugus valley other than those already controlled by the Wakefield Water Company they should be required to pay to the city of Lynn a fair proportion of the amount already paid by said city for water or land damages, and if they should utilize to any extent works previously constructed by the city they should pay a fair proportion of the cost of these works.

The Board advises your company to make investigations with reference to obtaining a further supply of water from the ground in the Saugus valley, in the territory referred to in your application, and will advise you further when the results of such investigations are presented. The greatest care should be exercised to prevent the pollution of your present source of supply by the increasing population on its watershed.

**WALPOLE.** The committee on water supply of Walpole applied to the State Board of Health March 9, 1893, for its advice relative to a public water supply for the town, to be taken from the ground in the valleys of Mill Brook and Traphole Brook in East Walpole, tributaries of the Neponset River. The Board replied as follows : —

Boston, April 10, 1893.

In accordance with your request for an early reply to your application relative to a water supply for the town of Walpole, the State Board of Health has caused a preliminary examination to be made, and finds that the local conditions favor the plan of taking a supply from the ground within the limits of the town, as suggested in your application to the Board. As it is stated in your application that the different sources within the town are to be fully investigated, the Board will make a further reply regarding the merits of these sources after the results of the investigations have been received.

After considering the needs and interests of other towns in the vicinity of Walpole the Board finds no reason to doubt that Walpole should at the present time have the right to any source within its limits. There is one source, however, viz., Traphole Brook, in the easterly part of Walpole, which subsequently flows through the southerly corner of Norwood and then forms the northerly boundary of the town of Sharon, which may in the future be of value to some other community as a source of additional water supply ; and if it should be found that this source is not the best one for Walpole and works should be built to take a supply from another source, the Board is of opinion that any rights which are now

granted Walpole to take a supply from this source should cease. This could be accomplished by including in an act giving Walpole the right to take water from any source within its limits a provision that the right of the town of Walpole to take water from Trap-hole Brook shall become void when the town shall have selected some other source of water supply and introduced water therefrom.

The results of the investigations referred to in the foregoing letter of advice having been submitted, the Board made a further reply as follows : —

BOSTON, June 5, 1893.

The investigations made near the Neponset River, not very far above the Blackburn water privilege and just below Low Brook, showed very satisfactory results as regards the porosity of the material, the freedom with which water could be pumped from the test wells and the quality of the water. Taking these results in connection with an examination of the surrounding territory and the size of the streams, the Board finds no reason to doubt that an ample supply of excellent water can be obtained from a well or wells located in the porous material in this vicinity.

WALTHAM. The water commissioners of Waltham applied to the State Board of Health July 31, 1893, asking for a re-examination of their sources of water supply, and for the advice of the Board as to the measures requisite to improve the quality of the water supplied to the city, and to prevent the recurrence of the offensive tastes and odors which were liable to affect it. The Board replied as follows : —

BOSTON, Dec. 22, 1893.

An examination of your collecting well and distributing reservoir was made promptly by one of the engineers of the Board, and samples of water were taken for analysis, which showed that the conditions were on the whole substantially the same as they were on Oct. 3, 1892, when the Board replied to a similar application made by you, and advised protecting the water from the light both at the well and at the distributing reservoir. The results of these analyses were sent you; and, as you then decided to proceed at once with the covering of the well, it was thought best to defer making the formal reply until it was feasible to include in it the results of further investigations, to ascertain the character of the water entering the well at different points and the effect of covering the well.

An examination was made to ascertain the temperature of the water entering the well at the bottom, at different points around its circumference, and it was found from thirteen observations, made on Sept. 9, 1893, that the average temperature of the water entering the well was 55.7 degrees, while at the same time the temperature of the river water was 68 degrees. These results indicated that no large proportion of the water filtered from the river by any very direct course, but there was a slight difference (3.4 degrees) in the temperature of the water at different points, which indicated that there might be a difference in the source and quality of the water entering different parts of the well. An attempt was therefore made to obtain samples of water entering the well at different points at the bottom, before it had mingled with the water already in the well, but it was not found feasible to do this.

Since the well has been covered two samples of water have been received from it, one collected November 14, and the other Dec. 12, 1893. These samples are entirely free from the microscopical organisms which were always found in the well before it was covered, and are clear, colorless and free from odor.

It is now feasible for the first time to ascertain the true chemical character of the water which enters the well, because, before it was covered, its character changed so rapidly, owing to the vegetable growths in the water, as to materially affect the results. There is nothing in the present analysis of the water to indicate that it is at the present time other than an excellent water for the purposes of a public water supply. The free ammonia, however, is somewhat higher than it would be in a water which had received the highest degree of purification by filtering through the ground, and it will be of interest to observe subsequent analyses of the water to see whether this constituent increases or diminishes.

With regard to the samples from the distributing reservoir it may be said that they show that the water in the reservoir is in substantially the same condition as in the past, and that it contains an abundant growth of the minute vegetable forms which give the water an unpleasant taste and odor.

The Board would therefore repeat its advice of last year, that by covering your present reservoir or building a new covered reservoir, as may be found best, you provide for conveying the water from the source to the water consumers without permitting it to be exposed to the light at any place.

WEBSTER. The water commissioners of Webster applied to the Board, June 23, 1893, for its advice relative to taking

a supply of water from the ground near Lake Chaubunagungamaug. The Board replied as follows : —

Boston, Oct. 6, 1893.

The State Board of Health has considered your application with regard to a proposed water supply for the town, to be taken from a well located near Lake Chaubunagungamaug, and has caused an analysis of a sample of water from a test well at the site of the proposed well to be made, also an examination of the surrounding territory. The analysis shows that the water is very pure and soft.

The sample probably represented water which was percolating through the ground toward the pond ; while if a large quantity of water should be pumped from the ground at this place, it is probable that a part of it would be derived by filtration from the lake. Judging from the experience at other places in the State, the water obtained in this way from the lake would be so thoroughly changed in its character by filtration that it would not differ to any noticeable extent from the water coming to the well from the land side.

Both the examination of the ground at the site of the well, made under your direction, and a general examination of the surrounding territory, indicate that a large quantity of water can be collected from the ground at this place ; and if the supply should prove insufficient, a supplementary supply of very good surface water can be obtained from the lake. It is desirable, however, that a full supply should be obtained from the ground, on account of the better quality of the water from this source.

WESTBOROUGH. The water commissioners of Westborough applied to the Board for advice, Sept. 26, 1892, relative to the improvement and increase of the public water supply, submitting at the same time a description of a proposed plan. The chief engineer of the Board visited the town, and made such suggestions as seemed necessary for the modification and improvement of the plan, and a new plan was submitted to the Board, Jan. 19, 1893. The Board replied as follows : —

Boston, Feb. 13, 1893.

Your water supply is now derived from two reservoirs, the upper one a storage reservoir of considerable size and the lower one a smaller basin which derives its supply from the upper one by the filtration of the water through the intervening porous ground. You find that the quality of this filtered water is very much better

than that of the water in the upper reservoir, but that at times the quantity is not sufficient to supply all of the water needed, and you therefore have to draw some of the water directly from the upper reservoir; moreover, the upper reservoir sometimes overflows into the lower one, injuriously affecting the quality of the water in it.

What is now desired, therefore, is a means of increasing the supply of filtered water during portions of the year and a means of diverting the overflow of the upper reservoir from the lower one.

The plan now submitted shows a contemplated channel for diverting the waste water from the upper reservoir past the lower one, and with the accompanying communication explains the result of certain tests which have been made with reference to the present conditions under which water is now filtering from one reservoir to the other, and of other tests made to determine the means by which the filtration may be facilitated.

Judging from the experiments which you have made, it seems quite certain that a material increase in the amount of filtered water can be obtained at a moderate expense by digging a ditch with sloping sides down into the sand and gravel at the shore of the upper reservoir between the dam and the waste way, this ditch to be separated from the water in the reservoir by an embankment extending above high water mark. This ditch should also be divided into sections, each of which should communicate with the reservoir by means of a pipe provided with a gate by which the water can be shut off during those portions of the year when enough water naturally filters through the ground, or when it becomes necessary to clean any section of the ditch so as to expose a fresh sand surface. The pipe and bottom of the ditch should either be placed at the lowest practicable level in the beginning, so that the system will operate when the upper reservoir is drawn down several feet, or they may be placed at a higher level in the beginning and subsequently lowered when the water recedes.

The experiments show that a ditch of this kind would let the water into the ground much more freely than it now gets in through the nearly impervious material at the bottom of the reservoir.

On the opposite or north side of the waste way a similar construction could be used to facilitate the filtration of water, but the ditch should be placed far enough back from the edge of the reservoir so that it will be wholly in clean sand or gravel below the surface of the water in the reservoir.

The contemplated filtering drain, intended to collect water from the ground and discharge it into the lower basin, if placed with its bottom nearly at the level of low water in the lower basin, would

undoubtedly increase to a considerable extent the quantity of filtered water. To avoid the danger of imperfect filtration, however, it would be desirable to limit its length to 150 feet from the shore of the lower basin rather than to make it 235 feet long, as shown upon the plan. This drain should connect with the lower basin by a pipe provided with a gate so that it can be shut off during those portions of the year when enough water naturally filters through the ground, and thus avoid an unnecessary draft upon the upper reservoir.

The new channel to divert the overflow from the upper reservoir past the lower basin is a very desirable feature, and if by removing the soil and fine material this channel can be prepared so that all the material beneath it will be sand or gravel it may also be feasible to use it as a supplementary filtration area in cases of emergency. In order to do this it would be necessary to lay a pipe to bring water from the upper reservoir to the channel, and to erect temporarily a low dam near its lower end.

WEST SPRINGFIELD. The water commissioners of West Springfield applied to the State Board of Health May 1, 1893, for its advice relative to taking an additional water supply from certain specified sources in that town and in Agawam. The Board replied as follows: —

BOSTON, June 1, 1893.

The State Board of Health has considered your application with regard to a proposed additional water supply for your town, including the village of Mittineague, which is at too high a level to be supplied from the present source. You have called the attention of the Board to the Craig Spring and Silver Stream, which can be utilized to supply the village of Mittineague by pumping, to the Leonard Brook in Agawam, which can be used to supply a portion of the lower village by gravity, to the Lathrop Spring and Hyde Brook, which can be diverted into the present reservoir, and to a more distant source, viz., a spring and brook at the Bear Hole, so-called, in the north-westerly part of the town, from which water would have to be supplied by pumping.

All of these sources have been visited by the engineer of the Board, and from all except Silver Stream samples of water have been collected and analyzed, and copies of the analyses are transmitted herewith, together with the average analysis of water from the present storage reservoir for the year ending in May, 1888.

The Craig Spring will furnish a soft water, and one of very good quality, provided it is collected by means of pipes leading to a



well, or by other suitable works, without exposure to the light, and when pumped is stored in a reservoir which is also covered to exclude the light. Care would also have to be taken to prevent any contamination by surface water running down the ravine in which the spring is situated.

The water of the Leonard Brook is soft and of very good quality.

The sample of water from the Lathrop Spring was necessarily collected after the water had passed through a rank growth of vegetable matter, which may have affected the analysis to some extent. This water is harder than the other waters examined. There seems no reason to doubt, however, that if taken directly from the ground and diverted into the present reservoir it would not change the character of the water in the reservoir enough to be objectionable.

The sample from Hyde Brook had a moderate color, indicating that this water is affected to some extent by contact with vegetable matter in swampy places. At the time the sample was collected, the water, though not as desirable as the spring waters, would be classed as a fairly good water for all purposes, but it is not feasible to tell from a single examination in the spring of the year what the character of this water would be in summer.

The water of the spring at the Bear Hole is of excellent quality, though its hardness is about twice that of the present water supply. The degree of hardness, however, is not great enough to make the water objectionable for water supply purposes. Bear Hole Brook, at the time the sample was collected, was receiving the overflow from Ashley Pond, and the quantity of water was unusually large. Under these circumstances the analysis would have but little value as an indication of the average quality of the water. The water had less color than Hyde Brook, but contained rather more organic matter. The degree of hardness was nearly the same as that of the water from the spring near it.

The plan proposed by you, of establishing a pumping station at the Craig Spring and supplementing the present supply to the lower village by introducing water from Leonard Brook, and connecting the Lathrop Spring with the present reservoir, has the merit that it will add to the present supply a considerable quantity of very good water by a comparatively small expenditure, and it may be wise to carry out this plan. The Board does not, however, have sufficient information as to the capacity of the present source in very dry years, or as to the amount which the supplementary sources will furnish in such years, or can be made to furnish by the construction of additional storage reservoirs, to enable it to advise definitely as to whether it is better to carry out this plan to

make the Craig Spring and the present reservoir the main source of supply, to be supplemented by such other sources in the vicinity as will supply the lower village by gravity, or whether it is better to go at once to a greater distance to obtain a supplementary supply from a source which will furnish a larger quantity of water. In order to obtain such information it would be necessary for you to employ an engineer skilled in the design and construction of water works to make a more complete study of this question, and the Board advises that this be done.

WHITMAN. The committee on water supply of the town of Whitman applied to the Board, April 12, 1893, for its advice relative to a public water supply from certain specified sources in that town and the towns of Hanson and Pembroke. The Board replied as follows:—

Boston, May 4, 1893.

In this application you make special mention of Maquam, Oldham and Big Sandy Bottom Ponds and Silver Lake. The Board has caused examinations to be made of these and other ponds in the vicinity. Complete chemical and microscopical examinations have been made of samples of water from Maquam, Oldham, Furnace and Big Sandy Bottom Ponds and Silver Lake, and less complete examinations of samples from Indian Head Pond and Factory Pond in the town of Hanson and Stetson's Pond in the town of Pembroke. Copies of these analyses are transmitted herewith.

The water of Indian Head and Factory ponds has a very dark color, and in other respects these ponds are less desirable than some of the others, so that they may be discarded from the list of desirable sources. Stetson's Pond presents no advantages either as to the quality or quantity of water as compared with Oldham Pond, and on account of its greater distance is a less available source for Whitman.

The water of Maquam Pond is practically colorless and in most other respects is a very satisfactory pond water. It had, however, at the time of the examination slightly more odor after standing in a bottle, and contained a greater number of microscopical organisms than any other sample of which a complete examination was made. All surface waters contain a greater or less number of these minute organisms, which are the cause of the odors noticed, and both the numbers and the amount of odor are liable to vary from time to time, so that too much significance should not be attached to the comparisons of only a single series of analyses. It is not feasible to tell from the information at present available whether or not Maquam Pond will furnish sufficient water to meet the requirements of the town of Whitman even in the near future, and this

source should not, therefore, be adopted in any case without making provision for supplementing the supply from some other source when necessary. In order to form an opinion as to whether this pond will furnish enough water to warrant taking a supply from it in the beginning, it would be necessary for you to ascertain by surveys the size of the watershed from which its supply is derived, and to make investigations to determine how much, if any, water is liable to be lost by filtration through the ground into other ponds.

Oldham Pond will furnish an abundant supply for the town for a very long time in the future, and the analysis indicates that the water is of fairly good quality at the present time. It has only a moderate amount of color and contains about the usual amount of organic matter, and in its present condition would be a satisfactory water for all purposes of a public water supply, though not as good as either the water of Maquam Pond or Silver Lake.

The analysis of a sample of water from Furnace Pond differs but little from that of a sample collected from Oldham Pond, but Furnace Pond has no advantages which should lead to its selection as a source of water supply for Whitman.

The water of Silver Lake is practically colorless and in other respects it is a better water than any other of the waters analyzed. This would undoubtedly be a satisfactory source both with regard to quantity and quality.

Big Sandy Bottom Pond has been used for years by the towns of Abington and Rockland and has proved to be an excellent water. The quantity which this source will furnish is more than the amount of water consumed by the three towns of Abington, Rockland and Whitman at the present time, so that for a time this source might be sufficient for all of the towns, but at a later period it would be necessary either to supplement the supply from some other source or for one of the towns to introduce an independent supply.

The information now in possession of the Board with regard to the proposed sources of water supply is too limited to enable it to advise as to the most appropriate source for the town, and it makes this preliminary reply at the present time because it understands that it is desired for use at a town meeting to be held soon. The Board would advise that a survey be made, as before suggested, to determine the size of the watershed of Maquam Pond, and that analyses should be made monthly of the waters of Maquam and Oldham ponds and of Silver Lake to determine the relative quality of these waters throughout the summer. The State Board of Health will co-operate with you by causing these analyses to be made if you will collect the samples of water, and will advise you further with regard to the proposed sources if you so request.

## SEWERAGE AND SEWAGE DISPOSAL.

The following is the substance of the action of the Board in reply to applications for advice relative to sewerage and sewage disposal : —

ANDOVER. The sewer commissioners of Andover, having been authorized by the town to report a plan of sewerage to the town, applied to the State Board of Health, June 8, 1893, stating that before reporting a general plan to the town they desired to know whether such a plan, involving the discharge of crude sewage into the Shawsheen River, would be approved by the State Board of Health. The Board replied as follows : —

Boston, July 7, 1893.

The Board is of opinion that, while it is not permissible to discharge the sewage of any large portion of the town into this river, it may be permissible for the present to discharge the sewage from the low land bordering the river into the river below the dam at Frye Village. In making a sewerage plan, therefore, provision should be made for carrying as much of the sewage of the town as can be conveyed by gravity, either to suitable porous land, where it can be purified by filtration before being discharged into the Shawsheen River, or to the Merrimack River.

ATTLEBOROUGH. The committee on drainage of the town of Attleborough applied to the State Board of Health, Jan. 16, 1893, for its advice relative to “the drainage of that portion of the village and town located on the watershed of Thacher Brook.” The Board replied as follows : —

Boston, Feb. 6, 1893.

The plan submitted shows the general character of the proposed improvement, which provides for lowering the channel of Thacher Brook, either in its present or a new location, and the substitution, for a portion of the way, of a covered drain for the open channel.

It is understood from the statements made by your committee that it is not proposed to turn any sewage into this channel, but that the sewerage system when constructed will convey the sewage in separate pipes in some other direction. Your committee has also indicated that it is very desirable to lower the level of the ground water in the upper part of the Thacher Brook watershed and near the central portion of the village, in order to avoid damp

or wet cellars, and thereby to improve the sanitary condition of this portion of the town. The high level of the ground water in this part of the village is also shown upon a plan previously submitted to the Board giving the level of the ground water.

The Board finds that the plan now proposed is one to be commended. It is certainly very desirable, for sanitary reasons, that the level of the ground water in the built-up portions of this watershed should be lowered, and it is wise to provide for the improvement of the lower portions of this brook before the design and location of a new channel are hampered and the cost increased by the construction of streets and buildings in the vicinity of the brook.

In addition to the improvement of the main channel the plan also indicates where branch drains emptying into the brook may be built in the streets in its vicinity. It would be desirable before constructing these drains that a complete system of sewerage should be designed for at least this portion of the town, both because the level of the ground water might be lowered by under-drains placed beneath the sewers, thereby rendering separate drainage channels unnecessary, and because the drains might otherwise be placed at such a height as to interfere with the proper grading of the system of sewers. These suggestions with regard to the branch drains may also be applicable to the extreme upper end of the main drain.

**BRAINTREE.** The committee on sewerage of Braintree applied to the State Board of Health June 5, 1893, for advice relative to a proposed system of sewerage for that town, and as to the comparative merits of certain areas proposed for sewage disposal. The Board replied as follows : —

Boston, July 6, 1893.

In this application you outline the general features of a proposed system for collecting the sewage, and suggest, as a method of disposal, pumping it to land where it can be purified. You then ask that the Board will cause the different tracts of land which are available for sewage disposal to be examined at as early a day as possible, and that the Board advise you regarding them.

Three tracts were called to the attention of the Board, one situated on the north-westerly side of Plain Street, just north of the Plymouth branch of the Old Colony Railroad, known as the Plain Street lot, another in the south-westerly part of the town, known as the Mayflower Park lot, and a third in the north-westerly portion of the town, known as the Collins Farm lot.

The Collins Farm lot is unsuitable for this purpose on account of its being located where the effluent from the sewage would find its way both into the present water supply of the city of Quincy and into the territory from which this city was authorized by the Legislature in 1891 to take an additional water supply.

At the Plain Street lot the test pits indicated that the material is of excellent quality for filtering sewage, and the principal objections to it are its proximity to the village of South Braintree and the limited area of suitable land which is available at this place. It is also an objection to this lot, though to a less extent than to the others, that it requires the sewage to be pumped a long distance from the lowest point in the town (where a pumping station would naturally be located), and to quite a high elevation.

At the Mayflower Park lot the test pits indicated that in addition to the coarser sand and gravel there were layers of very fine sand, which, while not preventing the use of the lot for the filtration of sewage, would require it to be applied in smaller quantities per acre, and would therefore require a greater amount of land to dispose of the sewage. The principal objections to the lot are its proximity to several houses, its limited area and the very great distance which the sewage would have to be pumped to reach it.

The amount of land required to purify the sewage of Braintree by intermittent filtration would depend both upon the quality of the land and upon the amount of sewage. In a general way it may be said that from 6 to 10 acres of filter-beds would meet all requirements for a few years, and that it is desirable to have not less than 20 or 30 acres in all to provide for future growth. It does not seem probable that this amount of land can be made available at either the Mayflower Park or the Plain Street location.

As a general result of this preliminary examination the Board is of opinion that, before adopting either of the tracts brought to its attention, it would be advisable for the town to cause examinations to be made to ascertain if a more satisfactory disposal of the sewage cannot be effected by discharging it into the sea at some suitable outlet. The nearness of the village of Weymouth to the lowest point in Braintree suggests that the interests of both communities might be served by united action by the towns of Weymouth and Braintree in the construction of an outlet to the sea; but even if it should be built by Braintree alone it may be cheaper and more satisfactory than the disposal of the sewage upon any of the areas examined up to the present time.

BROCKTON. The sewerage commissioners of Brockton applied to the Board, Sept. 14, 1892, for its advice relative

"3. Will the Board suggest the size of out-of-door filter-beds deemed necessary to make acceptable our second plant?

"4. Can loam be used over the sand in filter-beds?"

The application was accompanied by plans of the proposed plant at the location first indicated, which is an area of low ground bordering on the right or easterly bank of the Shawsheen River, between Main Street, Harding Street and the Boston & Maine Railroad; and subsequently a report was submitted relating to the proposed method of operation of the plant, and a sample of the sand intended to be used.

The essential features of the plan are settling tanks for the removal of the suspended matters from the sewage by sedimentation; filter-beds having an area of 2,800 square feet, and containing about 5 feet in depth of filtering material, through which it is expected to filter sewage from the settling tanks intermittently at a rate of 3,200,000 gallons per acre daily; and a secondary filter-bed, having an area of 2.3 acres, to be used for the filtration of the effluent from the first-mentioned filters by application to sand beneath a layer of loam. By the alternative plan, the last-mentioned filter-bed may be omitted, but the effluent in either case would be discharged into the Shawsheen River.

The Board has carefully considered the proposed scheme, and finds that it is a thoroughly impracticable one for the disposal of the sewage of the town of Andover.

The settling tanks into which the sewage would be discharged as it came from the main sewer cannot be expected to remove more than a very small portion of the suspended matter. Experiments at Lawrence with reference to the removal of organic matter from sewage by sedimentation have shown that by allowing sewage to settle for four hours about 18 per cent. of the organic matter, as indicated by the albuminoid ammonia, was removed. The consumption of water in Andover for the year 1894 averaged 328,000 gallons per day, and it is not unreasonable to expect that the amount of sewage to be disposed of after the sewerage system has come into general use may be in the vicinity of 200,000 gallons per day. With this quantity of sewage flowing, the time occupied by it in passing through the proposed settling tanks would not average more than two hours, or about one-half the time allowed in the experiments at Lawrence, and during the portion of the day when the flow was greatest the sewage would pass through the tanks in less time; moreover, there would be a constant flow of sewage through the proposed tanks, while in the case of the experiments at Lawrence the liquid was not disturbed.

The in-door filter-beds for the rapid filtration of the sewage after it has passed through the settling tanks are altogether inadequate for the purpose, and would very quickly become clogged, so that the required quantity of sewage could not be made to pass through them.

ing the works, the Board is of opinion that a pumping station should not be a source of offence to the neighborhood.

The provision of an overflow from the receiving reservoir and of blow-offs from depressions in the force main, where it crosses under the Salisbury Plain and Coweaset rivers, is a wise precaution; but these should be considered only as a provision for unforeseen emergencies and should never be used in the ordinary operation of the works.

The ground where the filter-beds are to be located has been very thoroughly examined by means of test pits. The material is of excellent quality for the filtration of sewage and the water level in the ground is at a considerable distance below its surface. These natural features, together with the careful manner in which it is proposed to construct the beds and their appurtenances, will permit them to be used for the disposal of an unusually large amount of sewage.

It has also been found, since the water supplied to the city has been pumped, and therefore measured, that the amount of water consumed per inhabitant is unusually small; and the amount of sewage will also be unusually small, in proportion to the population, if the ground water is kept out of the sewers, as is now proposed.

All of these facts lead the Board to conclude that the area to be used for filtration, although smaller than it is customary to recommend, will be sufficient for at least the first few years of the operation of the works, after which it will be necessary to extend the area.

The land in Brockton, lying easterly of the proposed filter-beds, which slopes from Pearl Street to the cranberry meadow, might be used to a limited extent for filtering sewage, but the test pits show that layers of an impervious clayey material are found in many places at from  $3\frac{1}{2}$  to  $6\frac{1}{2}$  feet below the surface and that the water stands in the ground much nearer the surface than on the other side of the street. This land could only be used to dispose of a comparatively small amount of sewage. The land in Brockton north of and across Daley Brook from the proposed filter-beds is better than that on the easterly side of Pearl Street but not as good as that where the filter-beds are located. This land would be fairly well adapted for the filtration of sewage.

The best land in this vicinity for the extension of the filter-beds lies just west of them, within the limits of the town of Easton. This land is similar in character to that where the filter-beds now proposed are located and is superior in quality, topography, character of material and distance from habitations to the land either east or north of them.



Since the proposed plan involved the taking of certain land within the limits of the city, further action of the Board was required under the provisions of chapter 124 of the Acts of 1890. A public hearing was therefore held by the Board, after which the following reply was sent to the mayor of Brockton : —

Boston, April 17, 1893.

The State Board of Health has received your petition dated March 25, 1893, made in behalf of the city of Brockton under the authority of chapter 124 of the Acts of 1890, entitled "An Act providing for the purchase or taking of land by cities and towns for the purification and disposal of sewage," asking the Board to approve the purchase or taking by said city of certain lands in Brockton for the purification and disposal of its sewage. Said lands are described in said petition and shown on an accompanying plan, as follows: "24 acres and 128.9 rods, being lands of Charles C. Manley; 20 acres and 58.7 rods, being lands of heirs of Salmon Copeland; 1 acre, being lands of David Frost; 2 acres and 73.28 rods, being lands of Milo Manley; 121.77 rods, being lands of Augustus Remick; 2 acres and 70.25 rods, being lands of George Howard."

In response to this petition the Board gave a public hearing at its office in Boston, on April 10, 1893, after due notice of said hearing by publication in the Brockton "Enterprise" and Brockton "Dispatch." Having thus complied with the requirements of the law the Board after due consideration herewith approves the purchase or taking of the premises described in said petition and shown upon the plan which accompanied it.

FRAMINGHAM. The selectmen of Framingham applied to the Board for advice relative to a proposed plan for the disposal of the water of the underdrain of the sewerage system of South Framingham, by pumping and final discharge into Bannister Brook. The Board replied as follows : —

Boston, Feb. 6, 1893.

Your application to the State Board of Health dated Jan. 23, 1893, for advice with regard to the disposal of the water, which is now discharged from the underdrain beneath the Framingham sewers into the water supply of Boston, by pumping this water into Bannister Brook at a point north of Hartford Street, beyond the watershed from which said supply is derived, has been carefully considered

The opinion of the Board with regard to the desirability of diverting this water from the water supply of Boston has already been given in its reply to the Board of Selectmen of Framingham dated Sept. 2, 1890.

With regard to the method of disposal now proposed, the principal features from a sanitary stand-point are the open reservoir near the pumping station, in which is to be stored the water from the underdrain during the night or at such other times as the pumps are not in operation, and the location of the final point of discharge. While it is not probable that the open reservoir will prove objectionable in any way yet the Board considers it advisable that it should be made as small as is consistent with a fair degree of economy in pumping. The capacity stated in the report which accompanied the application seems unnecessarily large.

With regard to the final disposal of the water from the underdrain by discharging it into the upper end of Bannister Brook north of Hartford Street, and beyond the watershed from which the city of Boston derives its supply, the Board is of opinion that this method of disposal is permissible for the present; but if the character of the water should deteriorate it may become necessary to discharge it upon a small filtering area, and it would be well to have the outlet where two or three acres of suitable filtering material may be secured.

**HOLYOKE.** The mayor of Holyoke applied to the State Board of Health, Feb. 13, 1893, for advice relative to a system of sewerage and sewage disposal for the villages of Elmwood, Oakdale and Springdale, having an outlet into the Connecticut River, opposite the trotting park in the lower part of the city. The Board replied as follows:—

Boston, March 2, 1893.

The Board is of the opinion that the sewage of these sections of your city may for the present be discharged into the river at the place indicated, but advises that the lower portion of the sewer should be so designed and constructed that the dry weather flow will be carried well out into the river by means of a pipe of moderate size leading from the bottom of the sewer, thereby preventing the fouling of the shore.

**LEICESTER.** The water commissioners of the water supply district of Leicester applied to the Board, Jan. 23, 1893, for advice as to a plan of sewerage and sewage disposal for

the village of Leicester. At a later date, March 1, they submitted a legislative document (House Document 385), stating that the committee on drainage requested that the bill accompanying the petition of the commissioners should be accompanied with the advice of the State Board of Health. The Board replied to this application as follows :—

Boston, March 3, 1893.

In reply to your request of March 1, relative to the application dated Jan. 23, 1893, of the Leicester Water Supply District, for advice in the matter of the disposal of the sewage of said district, the Board would state that it will be impracticable to advise until the snow disappears, so that a proper examination of the ground can be made.

With regard to the other matter mentioned, namely, the bill (House Document No. 385) extending the authority of the water commissioners of the district so that they shall also be a board of commissioners of main drains, common sewers, sidewalks and cross-walks, and providing that the district may raise money for carrying out the provisions of the act, the principal object appears to be to confer powers upon the district and its water commissioners with regard to the construction of main drains, common sewers, sidewalks and cross-walks, similar to those already possessed by towns and their selectmen. So far as the bill provides for the transfer of power from the town and its selectmen to the district and its water commissioners, the Board does not consider it within its province to advise.

In looking at the provisions of the bill in other respects, it is noticed that while it provides for the construction of main drains and common sewers, and for taking the land which may be necessary therefor, it does not authorize the construction of sewage disposal works or the taking of land for this purpose should the purification of the sewage be found necessary. The Board would therefore suggest that the bill might with advantage be modified so as to give the required authority in these respects, and herewith transmits a copy of the bill with suggested modifications to accomplish this result.

Should the Committee on Drainage think it advisable to limit the power granted to the water supply district with a view to preventing any improper disposal of the sewage, it might require the system of sewerage adopted and the land taken for sewage disposal, should any be required, to be subject to the approval of the State Board of Health. This might be accomplished by adding after the word "therefore" in section 5, line 8 : —

Provided, however, that any system or systems of sewerage, drainage or sewage disposal constructed under the provisions of this act shall be in general accordance with some plan or plans approved by the State Board of Health, and no land shall be taken for sewage disposal purposes without the approval of said Board.

The Committee on Drainage may also desire to restrict the territory within which land can be taken, by adding after the word "land," in section 5, line 7, the words "within the limits of the town of Leicester."

The final reply of the Board relative to this plan of sewage disposal was as follows : —

Boston, June 1, 1893.

The situation of the village upon the hill is such that nearly all of the sewage can be carried by a single system to the westerly side of the town in the vicinity of Rawson Brook, so called, or it is feasible to provide two systems, one of which would convey the sewage of rather more than half of the village to the above indicated location on the westerly side of the town, while the other would take the sewage from the remainder of the village in an easterly direction. An examination of the whole territory indicated that it would be well to take as much sewage as possible in a westerly direction to a point near the Rawson Brook.

After considering all of the conditions affecting the discharge of the sewage into Rawson Brook, the Board has reached the conclusion that such discharge should not be permitted even in the beginning until the sewage had been at least partially purified by the removal of the greater portion of the suspended matter. In the future a more complete purification of the sewage may be found necessary.

The best method of purification cannot be determined without a more extended examination of the ground than it is feasible for this Board to have made, and your town is therefore advised to employ a competent engineer to make the necessary surveys and devise a system for the purification of the sewage to at least the extent above indicated. The Board will advise further with regard to such system when the plans are submitted by you.

Where sewage is to be purified the smaller the amount of water to be taken care of, the less the difficulty of purification. The Board therefore commends your plan for adopting a system of sewers from which all storm water is to be excluded, and would further advise the exclusion of as much ground water as it is feasible to exclude.

The town of Leicester, having obtained an act from the Legislature requiring the approval of its plans by the State Board of Health (chap. 181, Acts of 1893), submitted plans to the Board, June 30, 1893, a statement of which, together with the approval of the Board, are as follows : —

Boston, Dec. 30, 1893.

Under the provisions of chapter 181 of the Acts of 1893, entitled "An Act to authorize the Leicester Water Supply District to construct and maintain a system of sewerage and drainage," the State Board of Health received from you on June 30, 1893, a written statement of your plan for the sewerage of the village of Leicester. This statement of your plan, as subsequently amended and submitted in a new draft dated Dec. 22, 1893, is as follows : —

13 BEACON STREET, BOSTON, MASS.

*To the State Board of Health.*

The water commissioners of the Leicester Water Supply District having received your reply of June 1, 1893, to their application for advice in relation to the disposal of the sewage of the village of Leicester, submit, for your approval, the following plans for its disposal.

In accordance with your suggestion, we propose to carry the sewage as far as possible to the westerly side of the village, and remove all the organic matter in suspension, so far as practicable, before discharging the effluent into Rawson Brook.

To accomplish this end, the separate water carriage system is to be adopted, to the extent of excluding all street or storm water, roof water and ground water, so far as feasible, the sewers to be flushed only when necessary with clean water from the mains.

The suspended matter is to be removed, as far as practicable, by allowing the heavier portion to settle in the tank (to be hereafter described), and by mechanical straining, if necessary, of the lighter part.

In order that the effluent may contain the smallest possible quantity of organic matter in solution, the separation is to be effected while the sewage is fresh.

The natural conditions of the location of the village on the slope of a hill are to be utilized as far as practicable by laying the sewers in accordance with approved forms of sewerage construction, to line and grade, with manholes at material changes of line and grade, at points of intersecting sewers, and wherever necessary, so as to insure easy cleaning out, and the most rapid flow and concentration of the sewage to the point of disposal.

For this purpose, 8-inch, 9-inch and 10-inch Akron salt-glazed pipe is to be used. Ground water is to be excluded by using cast-iron pipe when crossing wet, swampy land not easily drained outside of the highway, and by carefully making the joints and plugging the branches for particular sewers.

All the sewage for the present is to be collected at a point on Pine Street, 1,100 feet south of Main Street, and thence carried in a 10-inch pipe, laid at a grade of about 0.4 per cent., in a south-westerly direction, as shown by an accompanying plan, a distance of about 1,250 feet, to the top of a small knoll, and there discharged into a settling tank.

This tank is to be built either of brick or field stone, laid in cement mortar and plastered on the inside. It is to be covered with a roof or building. It is to contain not less than 600 cubic feet of sewage.

The overflow pipe from the tank is to be on the opposite side from where the sewage enters, and provision is to be made for breaking the force of the stream which enters the tank, so as to make the sewage flow quietly through it, and for preventing the floating scum from passing out through the overflow pipe.

The sewage passing from the tank is to be further purified as far as practicable by flowing it over land, or through a series of ditches, to Rawson Brook; but provision will be made so that the sewage will not have to run continuously in any one channel.

At the bottom of the tank an 8-inch gate connection with an 8-inch pipe is to be laid at a down grade of about one foot to the hundred to the point of discharge. Through this pipe the sewage or sludge which settles at the bottom of the tank is to be discharged once or twice a week, as may be necessary, upon ground thoroughly underdrained and levelled, so as to have a slight downward pitch from the point of discharge. This ground is to be ridged around the outer edge, so that the sludge may be distributed somewhat evenly over the surface. After the water which it contains has percolated through the drained surface, the solid refuse is to be carted away. Two or three beds of this kind will be prepared to be used alternately, and provision will be made for discharging the sludge brought by the 8-inch pipe upon them.

By extending the 8-inch pipe further in a southerly direction, other sludge beds can be prepared when necessary to meet future requirements.

It is proposed to acquire the knoll or ridge upon which the tank is to be located, and other knolls or ridges southwesterly therefrom, and all of the land between these knolls or ridges and Rawson

Brook, for the disposal of the sewage, and to purify the sewage upon this land as far as it may be found practicable to do so.

(Signed)

H. O. SMITH,  
C. W. WARREN,  
D. BEMIS,

*Water Commissioners.*

LEICESTER, Dec. 22, 1893.

The Board has caused a careful examination of the foregoing plan submitted by you to be made, and hereby approves said plan.

**NORTH BROOKFIELD.** The selectmen of North Brookfield applied to the State Board of Health, July 23, 1893, for advice relative to an extension of their existing system of sewerage and to an improved method of sewage disposal. The Board replied as follows:—

Boston, Sept. 8, 1893.

The plan, as set forth by the application and plans submitted, provides for the extension of the present main sewer to the northerly end of the town farm, the lower portion of said sewer to be an inverted siphon of iron pipe. At the outlet of the siphon a settling tank is shown, and provision is made for cleaning it by discharging its contents through an 8-inch pipe extending from the bottom of the tank down the hill to a sludge bed. The plan also shows another pipe extending down the hill, to serve as a main carrier of a system for distributing the settled sewage. The other carriers are not shown, but it is understood that they are to consist of ditches dug along the hillside, and having only a slight slope from the main carrier to their lower ends. It is further stated that the sewage can be turned upon about 17 acres of mowing and tillage land of a sandy nature, and thus dispose of the same by broad irrigation, and that there is other land upon the town farm which could be easily used in the future if necessary. The quantity of sewage at present is said to be about 50,000 gallons per day.

Under the conditions which exist in the present case it is advisable to screen the sewage, rather than to settle it, and thus avoid the possibility of producing offensive odors when the contents of the settling tank are discharged upon the sludge bed. The inverted siphon can undoubtedly be made to operate as now proposed, but it would be a desirable safeguard to adopt, to place screens above the entrance of the siphon, and thus prevent any large substances from getting into it. The satisfactory operation of the siphon would also be further insured by constructing an automatic flush tank above it, so that the sewage, instead of flow-

ing through it continuously in a sluggish stream, would pass through intermittently with a high velocity, and thus prevent the formation of putrefying deposits in the pipe. This intermittent discharge of the sewage would also facilitate its distribution over the land. The use of screens may be objected to on the ground that they will require excessive attention, but this objection can be overcome to a large extent by providing a very large screen area.

The changes as suggested would tend to decrease the cost of the work, as the screen chamber and flush tank should not cost any more than, if as much as, the proposed settling tank, sludge pipe and sludge bed; and by screening the sewage so that no large substances would enter the siphon pipe it would be feasible to reduce the diameter of this pipe to 8 inches.

With the present knowledge with regard to sewage disposal there would be a greater certainty of success if the sewage was discharged upon beds prepared upon the most porous part of the town land and disposed of by intermittent filtration. The proper preparation of these beds would include the removal of the black and yellow loam at the surface and the grading of the beds, so that the sewage could be evenly distributed upon them. It is probable, however, that, with the small quantity of sewage to be taken care of, satisfactory results may be obtained by the system of broad irrigation proposed by the town, and with less expense than by intermittent filtration, and the Board therefore thinks it proper that the town should begin to dispose of the sewage by broad irrigation. It would advise, however, that even in the beginning, several small beds, having an aggregate area of not less than one-half an acre, should be carefully prepared for intermittent filtration by the removal of the soil, for use at times when it is impracticable or inconvenient to dispose of the sewage by broad irrigation.

Where the sewage is disposed of upon a hillside by broad irrigation, there will be a tendency, if the sewage is allowed to flow long in one place, for it to gather in a stream and flow down the hill. To meet this contingency a large, level, intercepting ditch should be constructed around the lower part of the land, not less than 5 feet above the brook, to intercept streams of this character and prevent them from flowing unfiltered into the brook. Around other margins of the field small ditches should be dug to prevent the sewage from flowing off in these directions and convey it to the large intercepting ditch just mentioned.

In all cases of sewage disposal, and particularly where broad irrigation is adopted, the attainment of successful results depends to a very large extent upon the intelligent care taken to effect a proper distribution of the sewage.



**PITTSFIELD.** The city of Pittsfield presented to the Board, May 11, 1891, a plan of sewerage and sewage disposal, under the provisions of chapter 357, Acts of 1890, providing for the permanent disposal of sewage of the city by filtration upon land in the valley of the Housatonic River, with a temporary outlet into the river during the construction of the works. This plan was approved by the Board, May 12, 1891, with the provision that the direct discharge into the river should not continue after June 1, 1900.

On the 27th of December, 1892, the Sewer Commissioners applied to the Board requesting the following modification of the plan approved by the Board: "To strike out so much of said plan as designates specific areas of land for the permanent disposition of said sewage, and by striking out so much of said plan as provides that after the date therein specified all sewage is to be pumped to filtering fields across the river and there disposed of by intermittent filtration, and by inserting instead thereof a provision that after said date all sewage is to be permanently disposed of by such methods as the State Board of Health shall then approve." The Board replied to this application as follows:—

BOSTON, Jan. 10, 1893.

By the plan approved by the State Board of Health, above referred to, the Board permitted the use of the Housatonic River for the discharge of the sewage of Pittsfield until the year 1900, and after that date the sewage was to be cared for upon filtering areas of land and the discharge into the river stopped. The use of the river was therefore but for a brief period, and the main features of the general plan presented by the city of Pittsfield, and approved by this Board, provided for the ultimate care of the sewage upon the filtering areas. The changes now asked for, if approved by this Board, would leave the city of Pittsfield without provision for its future disposal of sewage other than the river. The Board is of opinion that such a course is not advisable for the city, nor does the Board feel it will do its duty should it approve any plan not fully providing for the future proper sanitary care of the city's sewage. The Board therefore cannot approve the amendments as proposed, but will consider any further plans in regard to the ultimate disposal of the sewage which the city may desire to present.

**PLYMOUTH.** The committee on sewerage of the town of Plymouth applied to the Board, March 30, 1893, for its advice

relative to a plan of sewerage and sewage disposal for that town. The Board replied as follows : —

Boston, June 14, 1893.

The plan referred to shows the outlines of a system of sewerage for the portion of the town from which sewage can be brought by marginal intercepting sewers to a point in Water Street just north of all wharves, and a 12-inch cast-iron pipe extending from this connecting point out into the harbor to the North Guzzle, so called. It is understood that the plan proposes the admission of storm water into the sewers from the main street of the town, but that elsewhere it is to be excluded. In order to provide for the disposal of the storm water, storm overflows from the marginal sewer are provided at four points along the shore.

The only important feature in which the Board advises a change is in the outlet pipe, which, in the opinion of the Board, should be changed so as to reach the Guzzle at a point as far from the shore as it is practicable to extend the pipe, but not more than 1,500 feet. The limit of 1,500 feet is mentioned because it is doubtful if a pipe longer than this could be kept free from deposits. In making the pipe longer, as advised, its size should be increased to 14 inches, which will not only offset the loss of capacity due to the greater friction of a longer pipe, but will also give a slight addition to the capacity, which is desirable.

The sizes and inclinations of the intercepting sewers appear to have been judiciously chosen, so far as can be judged from the preliminary plan submitted. These sewers of necessity are placed at a low level as compared with high tide, and have rather low grades, so that they may not prove wholly self-cleansing, but, even if they should not, the amount of care required to keep them clean would not be excessive. The cleaning of the southern branch of the intercepting sewer may be facilitated by the construction of an inlet as large as the sewer itself from the lower millpond on Town Brook, provided the millpond is at a sufficient elevation, this inlet to be used from time to time at low tide for flushing the sewer.

As a precaution against the clogging of the outlet pipe the Board would suggest the construction of a small chamber at its upper end, where it receives the sewage from the intercepting sewers. The bottom of this chamber should be depressed so as to act as a settling basin and catch any heavy material brought down by the sewers. It could be built in the street, but it would be better to construct it just outside the street lines and make it easily accessible. A gate at the upper end of the pipe, by which the water or

sewage could be held back in the sewers and then let out suddenly at low tide to flush the pipe, would be an advantage.

SPENCER. The superintendent of sewers of Spencer applied to the Board, June 1, 1893, for its advice relative to a system of sewage disposal upon land in the valley of Seven Mile River. The Board replied as follows : —

Boston, Dec. 8, 1893.

The Board finds from the statements contained in your application, and from the examinations made by one of its engineers, that the topography of the town is such that nearly all of the sewage can be collected by a system of sewers with a main sewer leading toward the Seven Mile River at a point south-westerly from the centre of the town, that the main sewer and a large part of the tributary sewers of this system have already been built, and that the sewage is now discharging into the river. It is the sewage from this main system which you propose to deal with at present.

The sewers already built are for the most part intended to take sewage only, but at a few points catch-basins have been built through which considerable storm water is admitted to the sewers ; and there is also a considerable amount of ground water finding its way into them, which materially increases the volume of sewage to be taken care of. The sewers also receive, in addition to the sewage proper, certain waste matters from the gas works in the town, which make the sewage particularly offensive and destroy the vegetation in the vicinity of the sewer outlet.

The town is situated on high land, and the main sewer falls rapidly until it reaches the lower land bordering the river. By intercepting the sewage before it reaches too low a level the sewage can be discharged by gravity upon land at a sufficient height above the river for sewage filtration. The suggestion has been made by you that the town now owns ten acres of gravelly land near the river, through which the present main sewer passes, which might be used for the disposal of sewage by intermittent filtration ; and that there are also about three acres of similar land adjoining the town lot on the south which might be used if additional area was required.

The material of the town lot, as determined by several test pits and by an examination of the surface of the ground, is of suitable quality for the disposal of sewage by the method suggested. The proper preparation of the lot for sewage disposal would involve the removal of the surface loam and the grading of the land into beds of suitable size, having a surface of porous sand or gravel.

In order to make the lower portions of the land available it would be necessary, after removing the surface loam, to raise them by filling with porous sand or gravel to a level six feet above ordinary high water in the river. The filter beds which have surfaces not more than 8 feet above the river should be underdrained. By taking the sand or gravel for this filling from the higher portions of the land and by building a few hundred feet of sewer in Main Street, so that the sewage will reach the lot at a higher level, it will be feasible to utilize all of the gravelly land, including the three acres lying south of the town lot.

It is desirable to restrict as far as practicable the amount of sewage to be taken care of, and in order to do this the surface water, which now enters the sewers through the catch basins in the streets should be disposed of in some other way. It is also desirable to diminish the amount of ground water, if, upon examination, it should be found feasible to do so. Should any large amount of ground water be found to enter the main sewer, or should it be found desirable to continue to dispose of the storm water through underground channels, it may be best to lay a new main sewer of much smaller size than the present one to take the sewage, reserving the present main sewer for the discharge of surface and ground water. The surface water which would naturally flow from adjacent high land upon the filter beds should also be collected and disposed of in such a way that it will not tend to saturate the beds. It may be feasible to turn this water into the lower portion of the present main sewer below the point where the sewage will be diverted from it to the filter beds.

It may be said, with regard to the disposal of the sewage of the town by intermittent filtration, that it is not probable that the results will be satisfactory unless the wastes from the gas works are excluded from the sewers, or, before being admitted, are treated in such a way as to make them inoffensive, and to remove all tarry or oily substances which would tend to clog the filter bed.

The area of suitable land at the town lot and the lot adjacent to it is smaller than is desirable, considering the large amount of ground water which finds its way into the sewers, and the increasing quantity of sewage which will enter the sewers as they are extended and the town increases in population. If the ground water could be excluded from the sewers, the area would be sufficient until the population of the town is considerably larger than at present.

In view of the somewhat limited area of land available at and near the town lot, examinations were made to determine whether additional land was available, and a tract was found, lying in a

south-westerly direction from the town lot, between the Brookfield road and the river, just beyond the cemetery, which appeared from a surface examination to be suitable for sewage filtration. This land is considerably higher than the river, but it is lower than the main sewer in Main Street, a short distance from the town lot, and the sewage could be conveyed to it through an iron pipe which would run full and under pressure. The lowest point in this pipe would be at the corner of Meadow and Main streets, nearly opposite the town lot, so that the pipe could be emptied frequently upon filter beds on the town lot, and thus kept clean. This tract of land is of suitable quality, and probably other land in this vicinity could be made available for the disposal of sewage.

While the town lot has a decided advantage, owing to its present ownership by the town and the ease with which sewage can be turned upon it, it will obviously be quite expensive to grade it and the small lot south of it so that the whole area of these lots will be available for sewage disposal, and unless the amount of sewage is materially diminished by the exclusion of ground water, it will be necessary to provide additional filtering area before long. It is therefore recommended that the town lot should not be finally adopted as the only site for filter beds until the other tract of land beyond the cemetery has been more carefully investigated, by digging test pits to ascertain if the material is porous and suitable for filtration; and, if so, whether it will not be cheaper to prepare the required area of filter beds partly at the town lot and partly at the lot beyond the cemetery; or, if not cheaper, whether it may not be desirable to control this second lot from the beginning, so as to have an opportunity to extend the filter-beds whenever it becomes necessary.

When you have the results of further surveys and estimates, or more definite plans of sewage disposal to submit, the Board will advise you further in this matter.

The Board is of the opinion that the discharge of the sewage directly into the Seven Mile River should be discontinued.

**WESTBOROUGH.** The committee on sewerage of the town of Westborough presented a general plan for the sewage disposal of the town, Feb. 3, 1890, which the Board approved (Senate Document 4, 1891, page 18). By a general Act of the Legislature of 1890, chap. 124, it was provided that land might be taken for sewage disposal with the approval of the State Board of Health after a public hearing. Under the provisions of this Act the selectmen applied to the Board

June 22, 1891. A hearing was held July 7, 1891, and the location submitted by the town was approved by the Board, July 8, 1891 (Senate Document 4, 1892, page 49).

In the following year, April 16, 1892, the selectmen of Westborough presented a plan, which, after due consideration, the Board deemed unsatisfactory and expressed such opinion in a communication to the selectmen, Nov. 3, 1892 (Senate Document 4, 1893, page 6), stating the conditions essential to success.

The selectmen again applied to the Board, Sept. 18, 1893, stating that the advice of the Board had not been carried out, and requesting the Board to "make an examination of the present sewage-disposal works of Westborough and advise the town further in the matter of sewage disposal." The Board replied as follows:—

BOSTON, Oct. 26, 1893.

In compliance with this request the Board has caused an examination of your present works to be made by one of its engineers. He finds that you have prepared filter-beds, having an area of a little more than two acres, by filling porous sand and gravel to a depth of from one to two and a half feet upon land from which the greater part if not all of the loam had been removed. From an examination by means of test pits dug at various points in the filter beds, he finds that the material beneath the upper porous layer is an extremely fine sand which not only remains saturated with water, but also keeps the porous material above it saturated for weeks after the discharge of sewage upon it has ceased. These conditions are unsuitable for the purification of sewage; and a very small quantity of sewage only could be disposed of upon these shallow beds if they were underdrained.

It was also found that a portion of the sewage was disposed of by being turned into a gravel pit, near the carrier, until the sewage stood in the pit to a depth of several feet, when it filtered into the ground quite rapidly, and the water reappeared in the form of a spring, a short distance away, clear but not thoroughly purified. It is highly improbable that this method of disposal would continue to give even as good results as at present for any long time in the future if any large proportion of the sewage should be turned into this pit. The rapidity with which the sewage disappears shows that the ground is porous in this vicinity, and that a good filter-bed might be prepared here which would successfully dispose of a portion of the sewage.

In reply to a previous application made by your board, the State

Board of Health sent to you on Nov. 3, 1892, a communication containing its advice in a general way as to what the town should do to properly dispose of its sewage. This advice, which the Board has no reason to modify, is as follows : —

The Board . . . . advises that the town should prepare filter-beds having a total area of not less than five acres for the disposal of its sewage. These beds should consist of sufficiently porous material to properly filter the sewage, and if of such a character or so situated that the ground-water level will not remain at least five feet below the surface of the beds, they should be efficiently underdrained.

The most economical method of preparing beds such as are here described is a matter which requires investigation. If a portion of your land can be found where there are two or three feet of porous material above the level of the water in the Assabet River, the required height of filter-bed can be obtained by filling gravel upon this portion after the loam or any other layer of very fine material which may be found has been stripped from it. If such land as is here described cannot be found, it may then be necessary to prepare beds by cutting down some of the higher gravelly land to the proper level, and filling the excavated material upon the low land, both the excavated and filled areas being used for filtration. The character of the material lying on the easterly side of a narrow swamp, and also easterly from the tract belonging to the town, appears to be of suitable quality for the construction of filter-beds by the last described method.

The Board cannot give you any more specific advice than that above given as to what should be done, because it is not feasible from such examinations as are made by its engineers to obtain the accurate data upon which such advice should be based in order to avoid wasteful expenditures and unsatisfactory results.

What you should therefore do is to employ some engineer skilled in this class of work to make plans of all the territory which may be used for sewage disposal, showing the height of the ground, the level of the water in the ground and the location of the test pits, which should be sunk at frequent intervals and to a sufficient depth to determine accurately the character of the material at different places with reference to its porosity. He should also determine where and how filter-beds can be constructed at a minimum cost, which will at least meet the requirements contained in the former reply of the Board.

If you should decide to make such investigations the Board will direct its engineers to co-operate with your engineer in the matter of determining the suitability of materials obtained from test pits for filtering sewage; and when the investigation is far enough advanced and new plans are presented the Board will advise you further regarding them.

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**EXAMINATION OF WATER SUPPLIES.**

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## ACTON.

## ACTON.

*Chemical Examination of Water from Tubular Test Wells in Acton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |               |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------------|---------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.        | Sediment.     | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1895.</b>        |                   |               |        |                         |          |             |           |             |           |                  |           |       |
| 14797   | Aug. 10             | Slight, clayey.   | Heavy, sandy. | .02    | 5.80                    | .0004    | .0004       | .22       | .0100       | .0000     | .0624            | 2.6       | .0050 |
| 14798   | Aug. 10             | Distinct, clayey. | Heavy, sandy. | .04    | 5.50                    | .0002    | .0000       | .22       | .0040       | .0000     | .0783            | 2.6       | .0100 |
| 15166   | Sept. 13            | Decided, clayey.  | Cons. earthy. | .04    | 6.70                    | .0000    | .0010       | .22       | .0030       | .0000     | .0406            | 2.6       | .0370 |

Odor, none. — The samples were collected from tubular test wells in Acton, which were located approximately as follows: No. 14797, 250 feet east of the town line between Acton and Boxborough and about 350 feet north of Massachusetts Avenue. No. 14798, about 340 feet east of the same boundary line and 500 feet north of Massachusetts Avenue. No. 15166, about 35 feet east of the boundary line and 280 feet north of Massachusetts Avenue. The analyses were made in connection with an investigation for a water supply for the town of Acton.

*Microscopical Examination.*

No organisms.

*Chemical Examination of Water from Fort Pond, Littleton, and Magog Brook and Magog Pond, Acton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|--------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                         | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |           |        |                                |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
|         | <b>1895.</b>        |             |           |        |                                |                      |          |             |            |                 |           |                |           |                  |           |
| 15784   | Dec. 20             | V. slight.  | V. slight | .30    | 3.10                           | 1.20                 | .0046    | .0170       | .0136      | .0034           | .23       | .0100          | .0001     | .3311            | 0.5       |
| 15785   | Dec. 20             | V. slight.  | Cons.     | .57    | 3.30                           | 1.55                 | .0004    | .0170       | .0126      | .0044           | .22       | .0100          | .0000     | .5390            | 0.5       |
| 16786   | Dec. 20             | V. slight.  | Slight.   | .10    | 2.45                           | 1.30                 | .0028    | .0332       | .0296      | .0036           | .30       | .0000          | .0000     | .2141            | 0.3       |

Odor, none; on heating, the first two samples had a faintly vegetable odor. — The samples were collected as follows: No. 15784, from Fort Pond, about 30 feet from the shore at the southerly end; No. 15785, from Magog Brook, about 50 feet above the road leading from Acton Centre to North Acton and about one mile below Magog Pond; No. 15786, from Magog Pond, near the road at the easterly end.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 15784, 123; No. 15785, 43; No. 15786, 41.

# EXAMINATION OF WATER SUPPLIES.

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## EXPLANATORY NOTE.

The systematic examination of the water supplies of the State was begun June 1, 1887, and has been continued up to the present time. The results for the years previous to 1893 have been published in four reports, as follows: June 1, 1887, to May 31, 1889, in the Special Report of the Board upon the Examination of Water Supplies (1890); June 1, 1889, to Dec. 31, 1890, in the Twenty-second Annual Report of the Board for the year 1890; for the years 1891 and 1892, in the Twenty-third and Twenty-fourth Annual Reports of the Board for those years. The present (Twenty-fifth Annual) report contains the results for the year 1893.

The first of these reports contained a description of each of the water supplies in the State existing at the date of that report. The later reports have described only new works and changes in existing works.

An alphabetical arrangement by towns has been adopted in this, as in previous reports. Sources of water supply are tabulated under the name of the town supplied, other waters under the name of the town in which they are situated. The analyses of water from the larger rivers not used as sources of water supply are given in a subsequent tabulation, headed "Examination of Rivers."

The chemical examinations in this report were made in the same manner as heretofore, and are presented in the tables in the same form as in the last report, except that a new determination, "Oxygen Consumed," has been added. This determination has been made for all waters this year, and appears in the tables of analyses for the first time. Owing to the space occupied by the column of "Oxygen Consumed," the "date of examination" of the samples has been omitted from the tables. The samples are usually received at the laboratory from twenty-four to forty-eight hours after collection.

All surface water and such samples of ground water as contain suspended matter are filtered through filter-paper before determining the color, the residue on evaporation and the albuminoid ammonia in solution. Some ground waters which are perfectly clear and colorless when drawn from the ground become turbid and colored on standing, in consequence of the oxidation of the iron which they contain. In these waters the residue on evaporation is determined without filtration, since this iron is an essential and not an accidental ingredient in the water. In the changes which accompany the oxidation of the iron in waters of this character, they become first cloudy (well described by the word *milky*) and finally deposit a precipitate of oxide of iron. In the cloudy condition they have a distinct color, which, while it does not have the same significance as in the case of surface waters and is only a passing phenomenon, is, nevertheless, of interest as showing a color which the water may assume while the oxidation of

the iron is in progress. When the iron is all oxidized and precipitated the water may become colorless again. Explanatory notes will be given for waters of this kind in connection with the tables of analyses.

The color of water is expressed by numbers which increase with the amount of color. The standard used is nesslerized ammonia, as described on page 531 of the Special Report upon the Examination of Water Supplies, 1890, and on page 329 of the Annual Report for 1893. Boston water, as drawn from a tap at the Institute of Technology, has had an average color for six years of 0.43. Other water supplies in the State have had an average color of from 0 to 1.45.

In cases where examinations of a source have been made with considerable regularity for several years, the averages of the results of the chemical analyses of previous years are appended to the tables of analyses for 1893.

In the microscopical examination of water there has been no change in the method employed since Nov. 6, 1890. This method was fully described in the Twenty-third Annual Report of the Board for the year 1891 (pages 395-421). Before Nov. 6, 1890, the methods employed were less perfect, so that a smaller proportion of the total number of organisms present in the water was separated from it and observed under the microscope; and, before drawing conclusions from a comparison of the microscopical examinations of waters made before and after this date, the explanatory note on page 70 of the Twenty-second Annual Report for 1890 should be read.

To indicate the amount of the so-called *Zoöglæa* observed, the number of individual masses is not counted, but an area equal to 2,500 square microns, or .0025 square millimeters, has been adopted as an arbitrary unit.

In publishing the results of the microscopical examinations the same system is followed as last year. The plants observed are classified in four groups, viz.: Diatomaceæ, Cyanophyceæ, Algæ and Fungi. The Animals observed are grouped as Rhizopoda, Infusoria, Vermes and Crustacea.

The names of the different genera in each group are given with the numbers of each per cubic centimeter, except that, to avoid making the tables excessively long, they are omitted when present only in very small numbers. It is not feasible to make with regard to omissions a single rule which will apply to all cases, because it is desirable to include smaller numbers of animals than of plants, and of the larger animals than of animals generally. Moreover, there are exceptional cases in which it is desirable to indicate the presence of even very small numbers of the more important plants or animals. Two general rules, however, have been adopted in printing the results, namely:—

1. All genera of Plants are included in which the total number observed in twelve months amounts to 6 or more per cubic centimeter, or in other words averages as much as 0.5 per month.

2. All genera of Animals are included in which the total number observed in 12 months amounts to 1.5 or more per cubic centimeter.

The larger microscopic animals, such as some of the Crustacea, are included, even when present only in very small numbers.

Fractions are generally omitted from the table, the nearest whole number of organisms per cubic centimeter being given. Where the total number of organisms observed is 0.5 or less, the fact that the organism was present is usually indicated by the abbreviation "pr.," but in the case of the larger organisms very small fractions are given.

## EXAMINATION OF WATER SUPPLIES.

## WATER SUPPLY OF ABINGTON AND ROCKLAND.

*Chemical Examination of Water from Big Sandy Pond, Pembroke.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 10032   | 1893.<br>Feb. 17    | V. slight.  | Slight.           | 0.02   | 2.10                            | 0.80                 | .0000    | .0086       | .0069      | .0026           | .58       | .0000          | .0000     | .1822            | 0.9       |
| 10058   | Feb. 27             | V. slight.  | V. slight.        | 0.02   | 3.05                            | 0.85                 | .0008    | .0130       | .0106      | .0024           | .68       | .0000          | .0000     | .1584            | 0.8       |
| 10196   | Mar. 31             | V. slight.  | Slight,<br>white. | 0.05   | 2.75                            | 0.85                 | .0060    | .0194       | .0130      | .0064           | .58       | .0030          | .0001     | .1825            | 0.5       |
| 10282   | Apr. 19             | Slight.     | Slight.           | 0.08   | 3.00                            | 1.20                 | .0000    | .0132       | .0112      | .0020           | .62       | .0000          | .0000     | .1861            | 0.3       |
| 10416   | May 17              | V. slight.  | None.             | 0.08   | 3.50                            | 1.55                 | .0010    | .0128       | .0110      | .0018           | .59       | .0030          | .0001     | .2372            | 0.5       |
| 10523   | June 14             | Slight.     | Slight.           | 0.10   | 3.65                            | 1.45                 | .0020    | .0170       | .0152      | .0018           | .62       | .0000          | .0000     | .2110            | 0.3       |
| 10650   | July 11             | V. slight.  | V. slight.        | 0.05   | 2.95                            | 1.10                 | .0012    | .0152       | .0132      | .0020           | .63       | .0050          | .0000     | .1971            | 0.5       |
| 10816   | Aug. 15             | Slight.     | V. slight.        | 0.10   | 3.35                            | 1.20                 | .0000    | .0128       | .0112      | .0016           | .62       | .0000          | .0000     | .2370            | 0.4       |
| 11024   | Sept. 13            | Distinct.   | Slight.           | 0.10   | 4.30                            | 1.90                 | .0000    | .0182       | .0152      | .0030           | .66       | .0000          | .0000     | .2340            | 0.3       |
| 11196   | Oct. 13             | V. slight.  | V. slight.        | 0.08   | 3.80                            | 1.75                 | .0002    | .0154       | .0142      | .0012           | .69       | .0000          | .0000     | .1944            | 0.3       |
| 11343   | Nov. 15             | Slight.     | Slight.           | 0.08   | 2.65                            | 0.85                 | .0000    | .0120       | .0104      | .0016           | .65       | .0030          | .0000     | .3029            | 0.3       |
| 11482   | Dec. 12             | Slight.     | Slight.           | 0.10   | 3.15                            | 0.80                 | .0006    | .0176       | .0156      | .0020           | .64       | .0000          | .0000     | .2336            | 0.3       |
| Av.     | .....               | .....       | .....             | 0.07   | 3.19                            | 1.19                 | .0010    | .0146       | .0122      | .0024           | .63       | .0012          | .0000     | .2130            | 0.5       |

Iron, .0048. Odor, generally vegetable or none once only disagreeable, disappearing on heating. — The samples were collected from a faucet at the pumping station, with the exception of No. 10,032, which was collected from the pond under the ice about 150 feet from the intake, and No. 10,650, which was collected from a drinking fountain near the center of the village of Abington.

## ABINGTON AND ROCKLAND.

*Microscopical Examination of Water from Big Sandy Pond, Pembroke.*

[Number of organisms per cubic centimeter.]

|                                | 1893. |       |       |       |       |       |       |       |       |       |       |       |
|--------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                | Feb.  | Mar.  | Apr.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, .          | 21    | 1     | 4     | 21    | 19    | 16    | 15    | 16    | 15    | 14    | 17    | 14    |
| Number of sample, .            | 10032 | 10058 | 10196 | 10282 | 10416 | 10523 | 10650 | 10616 | 11024 | 11196 | 11343 | 11482 |
| <b>PLANTS.</b>                 |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>Diatomaceæ, . .</b>         | 87    | 163   | 393   | 114   | 23    | 405   | 21    | 36    | 364   | 90    | 26    | 125   |
| Asterionella, . .              | 60    | 9     | 24    | 42    | 5     | 1     | 0     | 6     | 130   | 9     | 3     | 120   |
| Cyclotella, . .                | 1     | 2     | 98    | 18    | 0     | 400   | 18    | 24    | 32    | pr.   | 2     | 2     |
| Fragilaria, . .                | 4     | 0     | 4     | 2     | 0     | 0     | 0     | 0     | 14    | 0     | 0     | 0     |
| Melosira, . .                  | 0     | 0     | 2     | 2     | 0     | 1     | 0     | 1     | 108   | 73    | 3     | 0     |
| Navicula, . .                  | 6     | pr.   | 1     | pr.   | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 1     |
| Stephanodiscus, .              | 0     | 0     | 0     | 0     | 10    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Synedra, . .                   | 16    | 150   | 224   | 36    | 3     | 0     | 0     | 1     | 0     | 0     | 16    | 2     |
| Tabellaria, . .                | pr.   | 2     | 40    | 14    | 5     | 2     | 3     | 4     | 80    | 8     | 2     | 0     |
| <b>Cyanophyceæ, . .</b>        | 7     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 42    | pr.   | 50    |
| Chroococcus, . .               | 7     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Celosphaerium, . .             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 50    |
| Microcystis, . .               | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 42    | pr.   | 0     |
| <b>Algæ, . . . .</b>           | pr.   | 8     | pr.   | 18    | 5     | 0     | 0     | 0     | 9     | 0     | 12    | 4     |
| Protoecoccus, . .              | 0     | 8     | 0     | 0     | 5     | 0     | 0     | 0     | 9     | 0     | 10    | 0     |
| Staurogenia, . .               | 0     | 0     | pr.   | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 4     |
| Zoöspores, . .                 | pr.   | 0     | 0     | 18    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| <b>ANIMALS.</b>                |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>Rhizopoda, Difflugia,</b>   | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | pr.   | 0     | 0     | 1     |
| <b>Infusoria, . . .</b>        | 14    | 53    | 208   | 19    | 3     | 5     | 0     | 31    | 4     | 3     | 0     | 281   |
| Chlamydomonas, . .             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 200   |
| Dinobryon, . .                 | 0     | 7     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, .             | 14    | 44    | 208   | 16    | 3     | 4     | 0     | 30    | 2     | 0     | 0     | 80    |
| Peridinium, . .                | pr.   | 2     | pr.   | 3     | 0     | 0     | 0     | 1     | 2     | 3     | 0     | 1     |
| <b>Vermes, . . . .</b>         | 0     | 1     | 1     | 0     | 0     | pr.   | 0     | pr.   | 2     | 0     | 0     | 0     |
| Anurea, . . .                  | 0     | 1     | 1     | 0     | 0     | pr.   | 0     | 0     | 1     | 0     | 0     | 0     |
| Polyarthra, . .                | 0     | 0     | 0     | 0     | 0     | 0     | 0     | pr.   | 1     | 0     | 0     | 0     |
| <b>Miscellaneous, Zoöglæa,</b> | 7     | 3     | 7     | 14    | 0     | 16    | 44    | 2     | 28    | 18    | 40    | 10    |
| <b>TOTAL, . . . .</b>          | 115   | 228   | 609   | 165   | 31    | 426   | 65    | 69    | 407   | 153   | 78    | 471   |

## AMESBURY.

## WATER SUPPLY OF AMESBURY.—POWOW HILL WATER COMPANY.

*Chemical Examination of Water from the Works of the Powow Hill Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.           |            |        | Residue on Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-----------------------|------------|--------|-------------------------|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.            | Sediment.  | Color. |                         | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1893.</b>        |                       |            |        |                         |          |                  |           |             |           |                  |           |       |
| 10568   | June 27             | V. slight,<br>clayey. | V. slight. | 0.0    | 6.80                    | .0000    | .0034            | .63       | .1200       | .0006     | .0553            | 2.2       | .0000 |
| 10569   | June 27             | None.                 | None.      | 0.0    | 11.70                   | .0000    | .0004            | .63       | -           | .0000     | .0237            | 6.4       | .0000 |

Odor, none. — The first sample was collected from basin No. 1, which is supplied chiefly through tubular wells, and is the source from which samples have been collected in previous years. The last sample was collected from basin No. 2, a supplementary basin near No. 1.

*Microscopical Examination.*No. 10568. Infusoria, *Peridinium*, pr.; *Trachelomonas*, pr.No. 10569. Vermes, *Anurea*, pr.; *Rotatorian ova*, pr.

## WATER SUPPLY OF ANDOVER.

*Chemical Examination of Water from Haggett's Pond, Andover.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1893.   |                     |             |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 9892    | Jan. 18             | V. slight.  | Slight.    | 0.07   | 3.80                            | 1.35                 | .0066    | .0226       | .0136      | .0090           | .43       | .0030          | .0002     | .2409            | 1.4       |
| 10043   | Feb. 27             | V. slight.  | V. slight. | 0.10   | 3.30                            | 0.90                 | .0026    | .0144       | .0120      | .0024           | .33       | .0000          | .0000     | .2520            | 1.6       |
| 10122   | Mar. 15             | None.       | None.      | 0.08   | 3.40                            | 1.45                 | .0056    | .0150       | .0124      | .0026           | .34       | .0030          | .0001     | .1857            | 1.7       |
| 10262   | Apr. 18             | Slight.     | Slight.    | 0.10   | 3.15                            | 1.25                 | .0000    | .0132       | .0112      | .0020           | .29       | .0000          | .0000     | .2920            | 1.1       |
| 10408   | May 17              | Slight.     | Slight.    | 0.15   | 3.05                            | 1.00                 | .0000    | .0154       | .0136      | .0018           | .34       | .0090          | .0001     | .3212            | 1.0       |
| 10522   | June 15             | Slight.     | Slight.    | 0.20   | 3.35                            | 1.40                 | .0000    | .0174       | .0140      | .0034           | .31       | .0030          | .0000     | .3383            | 1.1       |
| 10656   | July 12             | V. slight.  | V. slight. | 0.08   | 3.30                            | 1.25                 | .0002    | .0162       | .0140      | .0022           | .34       | .0000          | .0000     | .3066            | 1.1       |
| 10863   | Aug. 17             | V. slight.  | V. slight. | 0.08   | 3.55                            | 1.90                 | .0000    | .0156       | .0124      | .0032           | .33       | .0000          | .0000     | .2691            | 1.0       |
| 11018   | Sept 13             | V. slight.  | V. slight. | 0.08   | 3.10                            | 1.30                 | .0000    | .0142       | .0126      | .0016           | .35       | .0030          | .0000     | .2418            | 0.9       |
| 11190   | Oct. 12             | None.       | V. slight. | 0.05   | 3.00                            | 1.55                 | .0000    | .0154       | .0140      | .0014           | .38       | .0000          | .0000     | .2875            | 1.1       |
| 11345   | Nov. 16             | Slight.     | Slight.    | 0.02   | 3.40                            | 1.25                 | .0000    | .0120       | .0096      | .0024           | .37       | .0030          | .0000     | .3195            | 1.6       |
| 11480   | Dec. 12             | V. slight.  | Slight.    | 0.10   | 3.15                            | 0.95                 | .0000    | .0102       | .0094      | .0008           | .31       | .0000          | .0000     | .2600            | 1.1       |
| Av.     | .....               | .....       | .....      | 0.09   | 3.30                            | 1.30                 | .0013    | .0151       | .0124      | .0027           | .34       | .0020          | .0000     | .2762            | 1.2       |

Iron, .0039. Odor, vegetable or none. — Nos. 10043, 10122, 10262, 10522 and 11480 were collected from a faucet in the pumping station; the remaining samples, directly from the pond.

## ANDOVER.

*Microscopical Examination of Water from Haggell's Pond, Andover.*

[Number of organisms per cubic centimeter.]

|                           | 1893. |       |       |       |       |       |       |       |       |       |       |       |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                           | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, .     | 20    | 28    | 16    | 19    | 18    | 16    | 15    | 19    | 14    | 13    | 17    | 14    |
| Number of sample, .       | 9892  | 10043 | 10122 | 10262 | 10408 | 10522 | 10656 | 10863 | 11018 | 11190 | 11345 | 11480 |
| <b>PLANTS.</b>            |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . .           | 3     | 178   | 28    | 126   | 210   | 372   | 90    | 35    | 16    | 3     | 91    | 93    |
| Asterionella, . .         | 0     | 4     | 3     | 5     | 106   | 8     | 0     | 27    | 13    | pr.   | 19    | 22    |
| Cyclotella, . .           | 0     | 156   | 24    | 44    | 76    | 360   | 86    | 6     | pr.   | 1     | 19    | 68    |
| Melosira, . . .           | 0     | 0     | 0     | 4     | 19    | 0     | 0     | 0     | 0     | 2     | 26    | 0     |
| Navicula, . . .           | pr.   | 0     | 0     | 3     | pr.   | 1     | pr.   | 0     | 1     | 0     | 1     | 1     |
| Synedra, . . .            | 1     | 16    | 1     | 64    | 7     | 1     | 4     | 2     | 1     | 0     | 4     | 2     |
| Tabellaria, . .           | 2     | 2     | 0     | 6     | 2     | 2     | 0     | 0     | 1     | 0     | 22    | 0     |
| Cyanophyceæ, . .          | 0     | 0     | 0     | 0     | 0     | 3     | 10    | 17    | 0     | 0     | 0     | 0     |
| Anabæna, . . .            | 0     | 0     | 0     | 0     | 0     | 2     | 10    | 6     | 0     | 0     | 0     | 0     |
| Clathrocystis, .          | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 11    | 0     | 0     | 0     | 0     |
| Algeæ, . . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 28    | 6     | 0     | 2     | 0     |
| Protooccus, . .           | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 24    | 6     | 0     | 0     | 0     |
| Raphidium, . .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 0     | 0     | 2     | 0     |
| <b>ANIMALS.</b>           |       |       |       |       |       |       |       |       |       |       |       |       |
| Rhizopoda, Euglypha, .    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 3     | 0     | 0     | 0     | 0     |
| Infusoria, . . .          | 0     | 0     | 0     | 5     | pr.   | 1     | pr.   | 4     | 3     | pr.   | 1     | 6     |
| Dinobryon, . . .          | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 3     | 0     | 0     | 0     | 0     |
| Dinobryon cases, .        | 0     | 0     | 0     | 4     | pr.   | 0     | 0     | 0     | 0     | 0     | 0     | 6     |
| Peridinium, . .           | 0     | 0     | 0     | 1     | 0     | 1     | pr.   | 1     | 2     | pr.   | pr.   | 0     |
| Trachelomonas, .          | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | pr.   | 1     | 0     |
| Miscellaneous, Zoöglæa, . | 0     | 7     | 0     | 0     | 0     | 36    | 24    | 0     | 2     | 32    | 50    | 0     |
| TOTAL, . . . .            | 3     | 185   | 28    | 131   | 210   | 412   | 124   | 87    | 27    | 35    | 144   | 99    |

## WATER SUPPLY OF ARLINGTON.

The advice of the State Board of Health to the town of Arlington relative to obtaining an additional water supply for the town and improving the quality of the present supply may be found on pages 9-12 of this volume. For analyses of samples of water from the wells mentioned in the reply to the town see the twenty-fourth annual report for 1892, pages 81-82. Additional analyses of water from these wells were made in 1893, and are given in this report on page 97.

## ARLINGTON.

*Chemical Examination of Water from the Brook just above the Storage Reservoir of the Arlington Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |             |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Sus-pended. |           |             |           |                  |           |
| 9885    | 1893.<br>Jan. 16    | V. slight.  | Slight.    | 0.20   | 7.75                    | 1.95              | .0090    | .0136       | .0112      | .0024       | .71       | .1000       | .0001     | .2387            | 3.4       |
| 10385   | May 12              | V. slight.  | Slight.    | 1.10   | 6.20                    | 2.45              | .0012    | .0208       | .0176      | .0032       | .52       | .0650       | .0002     | .7628            | 2.2       |
| 10636   | July 10             | Slight.     | Slight.    | 0.20   | 6.50                    | 1.90              | .0016    | .0116       | .0102      | .0014       | .64       | .0800       | .0001     | .2628            | 3.4       |
| 11039   | Sept. 18            | Slight.     | V. slight. | 0.18   | 8.45                    | 3.05              | .0002    | .0056       | .0062      | .0024       | .73       | .0750       | .0001     | .2652            | 3.3       |
| 11295   | Nov. 7              | Slight.     | V. slight. | 0.95   | 8.90                    | 2.55              | .0024    | .0202       | .0186      | .0016       | .75       | .0680       | .0004     | .8480            | 3.2       |
| Av.     | .....               | .....       | .....      | 0.56   | 7.02                    | 2.29              | .0044    | .0166       | .0141      | .0025       | .58       | .0722       | .0002     | .5107            | 2.9       |

Iron, .0149. Odor, vegetable or none; often becoming stronger on heating. — Water from this brook is drawn into the filter-gallery beside the reservoir and is thence supplied directly to the town, making it unnecessary to draw water from the reservoir except at times when the supply from the brook and filter-gallery combined is insufficient for the use of the town.

*Microscopical Examination.*

Average number of organisms, 177. The greatest number in any sample was 734 in March, consisting almost entirely of *Oreothrix* and *Zoëglæa*.

*Chemical Examination of Water from Tubular Test Wells at East Lexington.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         |                     |             |           |        |                         |          |             |           |             |           |                  |           |       |
| 11498   | 1893.<br>Dec. 14    | None.       | None.     | 0.08   | 7.30                    | .0076    | .0064       | .44       | .0080       | .0000     | .1560            | 4.0       | .0270 |
| 11523   | Dec. 19             | Slight.     | Slight.   | 0.12   | 7.85                    | .0092    | .0082       | .47       | .0090       | .0000     | .1539            | 4.0       | .0550 |
| 11552   | Dec. 27             | Slight.     | Cons.     | 0.15   | 7.70                    | .0106    | .0070       | .43       | .0180       | .0007     | .2100            | 4.6       | .0330 |

Odor of the first sample, none; of the second, none, becoming faintly vegetable on heating; of the last, very faintly vegetable, disappearing on heating. — The samples were collected during a pumping test from the same tubular wells that were tested last year. The test was begun on December 1, and pumping was continued at an average rate of 384 gallons per minute from 17 wells until after the second sample was collected. The third sample was collected while pumping from 13 wells at a rate of 287 gallons per minute.

*Microscopical Examination.*

No. 11498, no organisms. No. 11523, Fungi, *Oreothrix*, 60. Miscellaneous, *Zoëglæa*, 80. Total, 140. No. 11552, Fungi, *Oreothrix*, 64. Miscellaneous, *Zoëglæa*, 8. Total, 72.



## ASHBURNHAM.

## ASHBURNHAM.

*Chemical Examination of Water from Upper Naukeag Pond, Ashburnham.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                     | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>As |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|---------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>ignition | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                     |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 10140   | 1893.<br>Mar. 20    | Slight.     | Slight.    | 0.05   | 1.45                            | 0.60                | .0018    | .0094       | .0082      | .0012           | .10       | .0000          | .0000     | .1980            | 0.3       |
| 10267   | Apr. 19             | Slight.     | Slight.    | 0.10   | 1.75                            | 0.75                | .0012    | .0106       | .0088      | .0018           | .15       | .0030          | .0000     | .1606            | 0.0       |
| 10819   | Aug. 16             | Slight.     | V. slight. | 0.08   | 1.80                            | 0.90                | .0000    | .0682       | .0060      | .0022           | .11       | .0000          | .0000     | .2172            | 0.2       |
| Av.     | .....               | .....       | .....      | 0.08   | 1.67                            | 0.75                | .0010    | .0094       | .0077      | .0017           | .12       | .0010          | .0000     | .1433            | 0.2       |

Iron, .0020. Odor, none. — The samples were collected from the pond about four feet beneath the surface.

*Microscopical Examination of Water from Upper Naukeag Pond, Ashburnham.*

[Number of organisms per cubic centimeter.]

|                               | 1893.  |        |         |
|-------------------------------|--------|--------|---------|
|                               | March. | April. | August. |
| Day of examination, . . . . . | 21     | 20     | 17      |
| Number of sample, . . . . .   | 10140  | 10267  | 10819   |
| PLANTS.                       |        |        |         |
| Diatomaceæ, . . . . .         | 0      | 13     | 90      |
| Asterionella, . . . . .       | 0      | 0      | 35      |
| Cyclotella, . . . . .         | 0      | 0      | 52      |
| Synedra, . . . . .            | 0      | 7      | 0       |
| Tabellaria, . . . . .         | 0      | 6      | 3       |
| Cyanophyceæ, . . . . .        | 0      | 0      | 22      |
| Merismopedia, . . . . .       | 0      | 0      | 20      |
| Nostoc, . . . . .             | 0      | 0      | 2       |
| Algæ, . . . . .               | 0      | pr.    | 105     |
| Cosmarium, . . . . .          | 0      | pr.    | 2       |
| Protooccus, . . . . .         | 0      | 0      | 25      |
| Raphidium, . . . . .          | 0      | 0      | 76      |
| Staurostrum, . . . . .        | 0      | 0      | 2       |
| Fungi, Glaucothrix, . . . . . | 0      | 0      | 7       |

## ASHBURNHAM.

*Microscopical Examination of Water from Upper Naukeag Pond, Ashburnham.*

— Concluded.

[Number of organisms per cubic centimeter.]

|                                   | 1892.    |           |            |
|-----------------------------------|----------|-----------|------------|
|                                   | March.   | April.    | August.    |
| <b>ANIMALS.</b>                   |          |           |            |
| Infusoria, . . . . .              | pr.      | 7         | 11         |
| Dinobryon, . . . . .              | 0        | 6         | 0          |
| Dinobryon cases, . . . . .        | pr.      | 0         | 10         |
| Peridinium, . . . . .             | 0        | 1         | 1          |
| Vermes, Anurea, . . . . .         | 4        | 0         | 0          |
| Miscellaneous, Zoöglon, . . . . . | 0        | 36        | 36         |
| <b>TOTAL, . . . . .</b>           | <b>4</b> | <b>56</b> | <b>271</b> |

## WATER SUPPLY OF ATTLEBOROUGH.

In April, 1892, the town of Attleborough introduced water from a new source and abandoned its former source of supply near the Ten Mile River, in the thickly settled portion of the village.

The new source of supply is a large well about one hundred and fifty feet from Seven Mile River, just above Orr's Pond, — a mill pond at the confluence of Seven Mile River and Four Mile Brook. The well is thirty feet in diameter at the top and twenty-five feet deep. For the first five feet the material removed was a coarse compact gravel of a reddish tint. Beneath this was a stratum from two to six inches in thickness consisting of particles of coarse sand closely cemented together, and having a color somewhat resembling iron rust. Below this stratum to the bottom of the well, twenty-five feet beneath the surface, the material was a coarse sandy gravel in which no quicksand or very fine sand was found, and no stones of a greater diameter than eight inches. At the bottom of the well the material was very coarse.

A tubular well one and one-fourth inches in diameter was driven to a farther depth of twenty-five feet below the bottom of the well, without striking rock.

The walls of the well are of stone for a height of ten feet above the bottom, the first eight feet being laid without mortar. Above the stone work the walls are of brick masonry sixteen inches in thickness for a height of eight feet and twelve inches in thickness for the remaining ten feet, bringing the top of the wall about three

**ATTLEBOROUGH.**

feet above the surface of the ground. Light is excluded from the well by a wooden roof. A direct connection has been made with Orr's Pond for use in cases of emergency. Water is pumped from the well to the distributing system and to a covered iron tank.

During construction this well is said to have yielded water very freely.

*Chemical Examination of Water from the Well of the Attleborough Water Works.*

[Parts per 100,000.]

| Number.  | Date of Collection. | APPEARANCE.       |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|----------|---------------------|-------------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|          |                     | Turbidity.        | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 10266    | 1893.<br>April 17   | V. slight, milky. | V. slight. | 0.02   | 4.90                    | .0000    | .0030       | .35       | .0180       | .0000     | .0219            | 1.9       | .0065 |
| 10386    | May 12              | None.             | None.      | 0.03   | 4.60                    | .0000    | .0004       | .32       | .0280       | .0000     | .0219            | 2.2       | .0025 |
| 10811    | Aug. 15             | V. slight.        | V. slight. | 0.01   | 4.10                    | .0000    | .0006       | .31       | .0070       | .0000     | .0316            | 1.8       | .0060 |
| 11347    | Nov. 17             | None.             | None.      | 0.02   | 4.20                    | .0000    | .0000       | .43       | .0220       | .0001     | .0360            | 1.9       | .0140 |
| 11473    | Dec. 11             | None.             | None.      | 0.02   | 4.35                    | .0000    | .0000       | .40       | .0300       | .0000     | .0416            | 2.2       | .0050 |
| Av. .... | .....               | .....             | .....      | 0.02   | 4.43                    | .0000    | .0008       | .36       | .0210       | .0000     | .0312            | 2.0       | .0068 |

Odor, none.—The samples were collected from a faucet at the pumping station, while pumping.

*Microscopical Examination.*

No organisms.

**WATER SUPPLY OF AYER.***Chemical Examination of Water from the Ayer Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                 |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.       | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 10483   | 1893.<br>June 6     | None.       | V. slight.      | 0.00   | 5.30                    | .0000    | .0008       | .36       | .0500       | .0000     | .0647            | 2.1       | .0000 |
| 10784   | Aug. 12             | V. slight.  | Slight, earthy. | 0.03   | 5.60                    | .0004    | .0046       | .33       | .0550       | .0002     | .0624            | 2.3       | .0280 |

Odor, none.—The first sample was collected from the well used as a source of supply for the town; the last sample, from a faucet in the village, and may have consisted wholly or in part of water which had passed through the open distributing reservoir.

*Microscopical Examination.*

No. 10483. Miscellaneous, Zoöglæa, 5.

No. 10784. Diatomaceæ, Cyclotella, 4. Algae, Scenedesmus, 1. Fungi, Crenothrix, 2. Total, 7.

## WATER SUPPLY OF BELMONT.

BELMONT.

(See *Watertown.*)*Chemical Examination of Water from Clematis Brook in Belmont.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 10085   | 1893.<br>Mar. 7     | V. slight.  | V. slight. | 1.10   | 7.90                    | 3.15              | .0112    | .0296       | .0250      | .0046      | .53       | .0350       | .0003     | 1.0764           | 2.9       |

Iron, .0190. Odor, none; becoming vegetable on standing or heating. — The sample was collected from the brook at the point where it flows from a small mill pond known as Kendall's pond. The brook forms the boundary in this vicinity between Belmont and Waltham and is not used as a source of water supply.

*Microscopical Examination.*

Diatomaceæ, *Meridion*, 1; *Navicula*, 1; *Striatella*, 3. Miscellaneous, *Zoëglæa*, 3. Total, 8.

## WATER SUPPLY OF BEVERLY.

(See *Salem.*)

## BLACKSTONE.

*Chemical Examination of Water from Emerson and Ironstone Brooks and the Upper Ironstone Reservoir, in Uxbridge, and from Angelica Brook in Blackstone.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 11540   | 1893.<br>Dec. 22    | None.       | V. slight. | 0.70   | 3.90                    | 1.65              | .0000    | .0178       | .0160      | .0018      | .23       | .0050       | .0000     | .7728            | 0.9       |
| 11541   | Dec. 22             | V. slight.  | Cons.      | 0.12   | 3.55                    | 1.00              | .0004    | .0054       | .0036      | .0018      | .21       | .0050       | .0000     | .2352            | 0.5       |
| 11542   | Dec. 22             | None.       | V. slight. | 0.60   | 3.55                    | 1.55              | .0008    | .0154       | .0122      | .0032      | .25       | .0030       | .0000     | .7014            | 0.5       |
| 11543   | Dec. 22             | Slight.     | V. slight. | 0.53   | 2.40                    | 1.00              | .0022    | .0260       | .0200      | .0060      | .28       | .0070       | .0000     | .5628            | 0.6       |

Odor of all samples, vegetable. — The samples were collected as follows:—No. 11,540, from Emerson Brook at the saw mill dam in Uxbridge about half a mile above the point where the brook is crossed by the New York and New England Railroad. No. 11,541, from Angelica Brook just above the point where it is crossed by the New York and New England Railroad; this brook is a small stream which enters the Blackstone River from the south just below the village of Millville in Blackstone. No. 11,542, from Ironstone Brook just above the point where it enters the lower Ironstone Reservoir; No. 11,543 from the upper Ironstone Reservoir in the vicinity of the boundary line between Massachusetts and Rhode Island. The samples were collected during an investigation for a water supply for the town of Blackstone.

*Microscopical Examination.*

The number of organisms per cubic centimeter found in each sample was as follows: No. 11,540, 46; No. 11,541, 24; No. 11,542, 21; No. 11,543, 18.

## BOSTON.

## WATER SUPPLY OF BOSTON.

The principal change in the conditions affecting the character of the Boston water supply during 1893, is the filtration of the water of Pegan Brook through carefully prepared filter-beds of large area before it is discharged into Lake Cochituate. This brook drains the central portion of the town of Natick, which has no sewerage system.

The extension and increased use of the sewerage systems in Framingham, Marlborough and Westborough, has caused a still greater proportion of the sewage of these towns to be removed from the watershed of the Sudbury River than was the case last year.

The works of the Jamaica Pond Aqueduct Company were purchased by the city of Boston at the end of 1892, and the supply from this source has been permanently discontinued.

SUDBURY RIVER SUPPLY.—*Chemical Examination of Water from Cold Spring Brook, at Head of Reservoir No. 4, Ashland.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.        | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |             |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                   |            |        |                         |                   |          | Total.      | Dissolved. | Sus-pended. |           |             |           |                  |           |
| 9837    | 1893.<br>Jan. 2     | Distinct, clayey. | Slight.    | 0.60   | 2.60                    | 1.25              | .0006    | .0194       | .0164      | .0030       | .16       | .0030       | .0000     | .6789            | 0.9       |
| 9959    | Feb. 1              | V. slight.        | None.      | 1.00   | 5.05                    | 2.00              | .0020    | .0176       | .0152      | .0024       | .18       | .0090       | .0000     | .8833            | 1.4       |
| 10064   | Mar. 1              | None.             | V. slight. | 1.25   | 4.80                    | 2.25              | .0008    | .0208       | .0196      | .0012       | .26       | .0070       | .0000     | .9504            | 1.3       |
| 10199   | Apr. 3              | None.             | V. slight. | 1.10   | 3.20                    | 1.65              | .0002    | .0194       | .0176      | .0018       | .17       | .0030       | .0001     | .7774            | 1.4       |
| 10339   | May 1               | V. slight.        | Slight.    | 1.35   | 3.65                    | 1.75              | .0004    | .0220       | .0192      | .0028       | .24       | .0000       | .0000     | .9125            | 0.8       |
| 10463   | June 1              | None.             | V. slight. | 1.80   | 4.05                    | 2.45              | .0000    | .0238       | .0198      | .0040       | .26       | .0050       | .0001     | 1.1850           | 1.3       |
| 10587   | July 5              | Slight.           | Slight.    | 1.20   | 4.35                    | 2.45              | .0000    | .0302       | .0214      | .0088       | .24       | .0000       | .0000     | .9480            | 0.9       |
| 10717   | Aug. 3              | V. slight.        | V. slight. | 0.55   | 3.70                    | 1.20              | .0000    | .0208       | .0180      | .0028       | .28       | .0030       | .0001     | .5032            | 1.1       |
| 10952   | Sept. 1             | V. slight.        | V. slight. | 2.00   | 6.10                    | 3.45              | .0000    | .0392       | .0318      | .0074       | .28       | .0000       | .0000     | 1.5958           | 1.3       |
| 11122   | Oct. 2              | V. slight.        | None.      | 0.85   | 4.30                    | 1.95              | .0000    | .0190       | .0174      | .0016       | .29       | .0000       | .0000     | .6468            | 1.3       |
| 11273   | Nov. 1              | V. slight.        | Slight.    | 2.00   | 7.90                    | 3.80              | .0028    | .0424       | .0376      | .0048       | .49       | .0070       | .0002     | 1.7040           | 1.9       |
| 11434   | Dec. 4              | Slight, clayey.   | Cons.      | 1.05   | 4.50                    | 1.75              | .0086    | .0225       | .0202      | .0026       | .30       | .0000       | .0002     | .9321            | 1.4       |
| Av.     | .....               | .....             | .....      | 1.23   | 4.52                    | 2.16              | .0013    | .0248       | .0212      | .0036       | .26       | .0031       | .0001     | .9765            | 1.3       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1889* | - | - | 2.24 | -    | -    | .0025 | .0410 | .0385 | .0025 | .28 | .0056 | .0001 | -     | -   |
| - | 1890  | - | - | 0.91 | 4.49 | 2.01 | .0011 | .0243 | .0210 | .0033 | .24 | .0090 | .0001 | -     | 1.5 |
| - | 1891  | - | - | 1.30 | 4.87 | 2.30 | .0009 | .0297 | .0282 | .0035 | .23 | .0087 | .0001 | -     | 1.8 |
| - | 1892  | - | - | 1.44 | 5.15 | 2.57 | .0003 | .0308 | .0266 | .0042 | .25 | .0068 | .0001 | -     | 1.2 |
| - | 1893  | - | - | 1.23 | 4.52 | 2.16 | .0013 | .0248 | .0212 | .0036 | .26 | .0031 | .0001 | .9765 | 1.3 |

\* June to December.

NOTE to analyses of 1893; Iron, .0139. Odor, distinctly vegetable. — The samples were collected from the brook at its entrance into reservoir No. 4.

*Microscopical Examination.*

Average number of organisms in 1893, 63 per cubic centimeter.

BOSTON.

SUDBURY RIVER SUPPLY.—*Chemical Examination of Water from Reservoir No. 4, Ashland.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|--------------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.         | Sediment.  | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                    |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 9838    | 1893.<br>Jan. 2     | Slight.            | Slight.    | 0.45   | 2.65                            | 1.10                 | .0020    | .0154       | .0120      | .0034           | .16       | .0000          | .0000     | .4526            | 1.3       |
| 9960    | Feb. 11             | V. slight.         | V. slight. | 0.68   | 4.15                            | 1.70                 | .0086    | .0276       | .0250      | .0026           | .28       | .0050          | .0001     | .7482            | 1.3       |
| 10065   | Mar. 1              | V. slight.         | V. slight. | 0.90   | 3.90                            | 2.00                 | .0044    | .0198       | .0180      | .0018           | .20       | .0150          | .0000     | .7992            | 1.1       |
| 10200   | Apr. 3              | V. slight.         | V. slight. | 0.88   | 3.65                            | 1.75                 | .0012    | .0178       | .0154      | .0024           | .19       | .0100          | .0000     | .7008            | 0.9       |
| 10340   | May 1               | V. slight.         | Slight.    | 1.00   | 3.40                            | 1.35                 | .0014    | .0212       | .0188      | .0024           | .25       | .0090          | .0002     | .7117            | 0.6       |
| 10464   | June 1              | V. slight.         | V. slight. | 1.10   | 3.15                            | 1.85                 | .0000    | .0158       | .0132      | .0026           | .20       | .0070          | .0001     | .8147            | 0.8       |
| 10588   | July 5              | Slight.            | Slight.    | 0.90   | 3.35                            | 1.65                 | .0014    | .0256       | .0228      | .0028           | .16       | .0000          | .0000     | .8058            | 0.9       |
| 10718   | Aug. 3              | Slight.            | Slight.    | 0.70   | 3.15                            | 1.65                 | .0002    | .0188       | .0164      | .0024           | .26       | .0030          | .0001     | .6031            | 0.8       |
| 10953   | Sept. 1             | Slight.            | Slight.    | 0.55   | 3.00                            | 1.35                 | .0000    | .0198       | .0130      | .0068           | .24       | .0030          | .0000     | .6162            | 0.8       |
| 11123   | Oct. 2              | Distinct.          | Cons.      | 0.70   | 3.85                            | 1.75                 | .0000    | .0212       | .0170      | .0042           | .24       | .0000          | .0000     | .4897            | 0.9       |
| 11274   | Nov. 1              | Slight.            | Slight.    | 0.45   | 3.65                            | 1.25                 | .0000    | .0218       | .0158      | .0060           | .30       | .0000          | .0001     | .5400            | 0.9       |
| 11435   | Dec. 4              | Slight,<br>clayey. | Cons.      | 0.95   | 4.55                            | 2.15                 | .0090    | .0224       | .0200      | .0024           | .30       | .0060          | .0001     | .8658            | 1.4       |
| Av.     | .....               | .....              | .....      | 0.77   | 3.54                            | 1.63                 | .0024    | .0206       | .0173      | .0033           | .23       | .0048          | .0001     | .6773            | 1.0       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 0.74 | 3.71 | 1.51 | .0005 | .0246 | -     | -     | .25 | .0033 | -     | -     | -   |
| - | 1888  | - | - | 0.72 | 3.83 | 1.70 | .0007 | .0277 | -     | -     | .22 | .0054 | .0001 | -     | -   |
| - | 1889  | - | - | 0.85 | 3.48 | 1.98 | .0016 | .0251 | .0218 | .0033 | .23 | .0068 | .0002 | -     | -   |
| - | 1890  | - | - | 0.61 | 3.67 | 1.40 | .0008 | .0222 | .0191 | .0031 | .24 | .0096 | .0001 | -     | 1.7 |
| - | 1891  | - | - | 0.53 | 3.24 | 1.55 | .0006 | .0187 | .0156 | .0031 | .20 | .0062 | .0001 | -     | 0.9 |
| - | 1892  | - | - | 0.64 | 3.60 | 1.52 | .0002 | .0200 | .0168 | .0032 | .23 | .0061 | .0001 | -     | 1.1 |
| - | 1893  | - | - | 0.77 | 3.54 | 1.63 | .0024 | .0206 | .0173 | .0033 | .23 | .0048 | .0001 | .6773 | 1.0 |

\* June to December.

NOTE to analyses of 1893; Iron, .0118. Odor generally faintly vegetable, sometimes none; on heating the odor is generally somewhat stronger, but rarely unpleasant. The samples were collected from the reservoir near the gate-house one foot beneath the surface. — The surface of the water in this reservoir was from 18 to 21 feet below high water mark in January and during the next two months rose practically to high water mark, at which point it remained until August. On September first the water had been drawn down 14 feet below high water mark and during the remainder of the year on dates when samples of water were collected for analysis the reservoir never contained more than 9 feet of water and at the first of December was empty. For monthly record of height of water in this reservoir see table at end of Boston analyses.

## BOSTON.

SUDBURY RIVER SUPPLY. — *Microscopical Examination of Water from Reservoir No. 4, Ashland.*

[Number of organisms per cubic centimeter.]

|                           | 1893. |      |       |       |       |       |       |       |       |       |       |       |
|---------------------------|-------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                           | Jan.  | Feb. | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, .     | 3     | 2    | 2     | 4     | 2     | 2     | 6     | 4     | 2     | 3     | 2     | 6     |
| Number of sample, .       | 9838  | 9960 | 10065 | 10200 | 10340 | 10464 | 10588 | 10718 | 10953 | 11123 | 11274 | 11435 |
| PLANTS.                   |       |      |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . .           | 31    | pr.  | pr.   | pr.   | 15    | 324   | 141   | 48    | 40    | 9     | 490   | 36    |
| Asterionella, . .         | 9     | pr.  | 0     | 0     | 2     | 2     | 0     | 0     | 0     | 0     | 0     | 0     |
| Cyclotella, . .           | 11    | pr.  | pr.   | pr.   | 4     | 126   | 136   | 48    | 38    | 4     | 88    | 7     |
| Diatoma, . .              | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 240   | 3     |
| Fragilaria, . .           | 0     | 0    | 0     | 0     | 0     | 15    | 0     | 0     | 0     | 0     | 0     | 0     |
| Synedra, . .              | 11    | pr.  | 0     | 0     | 7     | 180   | 2     | 0     | 2     | 5     | 160   | 25    |
| Tabellaria, . .           | 0     | 0    | 0     | 0     | 2     | 1     | 3     | 0     | 0     | 0     | 2     | 1     |
| Algæ, . .                 | 3     | pr.  | 0     | 7     | 5     | 18    | 1     | 4     | 120   | 170   | 34    | 0     |
| Chlorococcus, . .         | 0     | pr.  | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 6     | 4     | 0     |
| Protooccus, . .           | pr.   | 0    | 0     | 0     | 0     | 17    | 0     | 0     | 0     | 0     | 8     | 0     |
| Raphidium, . .            | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 120   | 0     | 22    | 0     |
| Scenedesmus, . .          | pr.   | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 164   | 0     | 0     |
| Staurostrum, . .          | 3     | 0    | 0     | 0     | 0     | 1     | 1     | 2     | pr.   | 0     | 0     | 0     |
| Zoospores, . .            | 0     | pr.  | 0     | 7     | 5     | 0     | 0     | 1     | 0     | 0     | 0     | 0     |
| Fungi, Crenothrix, .      | 3     | 0    | 0     | 0     | pr.   | 0     | 0     | 0     | 0     | 8     | 2     | 0     |
| ANIMALS.                  |       |      |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . .            | 1     | 5    | 0     | 0     | 1     | 0     | pr.   | 1     | 0     | 4     | 2     | 0     |
| Dinobryon cases, .        | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     |
| Monas, . .                | 0     | 0    | 0     | 0     | 0     | 0     | pr.   | 0     | 0     | 1     | 0     | 0     |
| Peridinium, . .           | 1     | 4    | 0     | 0     | 1     | 0     | 0     | 1     | 0     | 3     | 0     | 0     |
| Trachelomonas, . .        | pr.   | 1    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | pr.   | 0     |
| Miscellaneous, Zoöglæa, . | 36    | 0    | 4     | 0     | 4     | 7     | 3     | 0     | 26    | 260   | 34    | 8     |
| TOTAL, . .                | 74    | 5    | 4     | 7     | 25    | 349   | 145   | 53    | 186   | 451   | 562   | 44    |

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Reservoir No. 4, Ashland, collected near the bottom.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                       | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                              |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 10011   | 1893.<br>Feb. 14    | Slight.     | Slight.    | 1.00   | 5.15                         | 2.15                 | .0042    | .0206       | .0190      | .0016           | .32       | .0180          | .0000     | .8235            | 2.0       |
| 10954   | Sept. 1             | V. slight.  | V. slight. | 0.72   | 3.15                         | 1.40                 | .0006    | .0168       | .0134      | .0034           | .24       | .0070          | .0000     | .6478            | 0.9       |

Iron, .0130. Odor, vegetable, becoming disagreeable on heating. — The samples were collected from the reservoir near the bottom. On the dates when the samples were collected the reservoir was only about half full.

*Microscopical Examination.*

No. 10,011. Diatomaceæ, *Cyclotella*, 8; *Synedra*, 2. Miscellaneous, *Zoöglæa*, 23. Total, 33.  
 No. 10,954. Diatomaceæ, *Cyclotella*, 32; *Synedra*, 5; *Tabellaria*, 2. Algæ, *Raphidium*, 8. Fungi, *Crenothrix*, 7. Rhizopoda, *Actinophrys*, 1. Vermes, *Anurea*, 1; *Polyarthra*, 1. Miscellaneous, *Zoöglæa*, 24. Total, 81.

## BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Sudbury River at the Upper End of Reservoir No. 2, Ashland.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|--------------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.         | Sediment.  | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                    |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1893.   |                     |                    |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 9839    | Jan. 2              | Decided.           | Cons.      | 1.00   | 5.20                            | 2.25                 | .0008    | .0278       | .0180      | .0098           | .28       | .0070          | .0000     | .9490            | 1.7       |
| 9961    | Feb. 1              | V. slight.         | Cons.      | 1.10   | 5.45                            | 2.25                 | .0064    | .0200       | .0166      | .0034           | .34       | .0100          | .0000     | .9271            | 1.4       |
| 10066   | Mar. 1              | Slight.            | Cons.      | 1.20   | 4.75                            | 2.05                 | .0052    | .0214       | .0196      | .0018           | .32       | .0050          | .0000     | .9072            | 1.6       |
| 10201   | Apr. 3              | V. slight.         | V. slight. | 0.85   | 3.15                            | 1.05                 | .0000    | .0148       | .0116      | .0032           | .19       | .0000          | .0000     | .6789            | 0.9       |
| 10341   | May 1               | Slight.            | Slight.    | 1.28   | 3.40                            | 1.55                 | .0006    | .0196       | .0176      | .0020           | .26       | .0050          | .0001     | .8249            | 0.8       |
| 10465   | June 1              | Slight.            | Slight.    | 1.50   | 4.10                            | 2.10                 | .0012    | .0258       | .0240      | .0018           | .28       | .0120          | .0002     | 1.0612           | 1.1       |
| 10589   | July 5              | Slight.            | Slight.    | 1.10   | 4.60                            | 2.15                 | .0042    | .0286       | .0236      | .0050           | .30       | .0090          | .0001     | .7636            | 1.4       |
| 10719   | Aug. 3              | Slight.            | Slight.    | 0.65   | 4.35                            | 1.95                 | .0010    | .0228       | .0204      | .0024           | .37       | .0070          | .0001     | .5624            | 1.3       |
| 10955   | Sept. 1             | Distinct.          | Slight.    | 0.65   | 3.65                            | 2.20                 | .0018    | .0234       | .0192      | .0042           | .26       | .0000          | .0000     | .6794            | 1.0       |
| 11124   | Oct. 2              | Slight.            | Slight.    | 0.50   | 5.25                            | 2.10                 | .0012    | .0188       | .0162      | .0026           | .57       | .0200          | .0001     | .4389            | 2.1       |
| 11275   | Nov. 1              | Slight.            | Slight.    | 1.20   | 5.10                            | 2.15                 | .0000    | .0286       | .0254      | .0032           | .45       | .0030          | .0002     | 1.0600           | 1.4       |
| 11436   | Dec. 4              | Slight,<br>clayey. | Cons.      | 0.90   | 5.80                            | 2.50                 | .0000    | .0270       | .0232      | .0038           | .42       | .0030          | .0003     | 1.0101           | 1.6       |
| Av.     | .....               | .....              | .....      | 0.99   | 4.57                            | 2.03                 | .0019    | .0232       | .0196      | .0036           | .34       | .0068          | .0001     | .8219            | 1.4       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 1.13 | 5.37 | 1.81 | .0021 | .0313 | -     | -     | .39 | .0170 | -     | -     | -   |
| - | 1888  | - | - | 1.19 | 4.76 | 2.07 | .0018 | .0293 | -     | -     | .29 | .0108 | .0002 | -     | -   |
| - | 1889  | - | - | 1.25 | 3.62 | 1.38 | .0013 | .0294 | .0267 | .0027 | .30 | .0080 | .0002 | -     | -   |
| - | 1890  | - | - | 0.82 | 5.18 | 2.09 | .0014 | .0256 | .0220 | .0036 | .30 | .0135 | .0001 | -     | 1.7 |
| - | 1891  | - | - | 0.85 | 4.35 | 1.81 | .0008 | .0274 | .0236 | .0038 | .26 | .0112 | .0001 | -     | 1.1 |
| - | 1892  | - | - | 1.00 | 4.71 | 2.08 | .0006 | .0247 | .0214 | .0033 | .28 | .0099 | .0001 | -     | 1.3 |
| - | 1893  | - | - | 0.99 | 4.57 | 2.03 | .0019 | .0232 | .0196 | .0036 | .34 | .0068 | .0001 | .8219 | 1.4 |

\* June to December.

NOTE to analyses of 1893, Iron, .0166. Odor, generally vegetable, occasionally mouldy or unpleasant, becoming somewhat stronger on heating. — The samples were collected from the river near the old dam at the upper end of Reservoir No. 2, at a depth of one foot beneath the surface.

*Microscopical Examination.*

Average number of organisms in 1893, 157 per cubic centimeter. The greatest numbers found were 738 in January, consisting chiefly of Zoöglæa and Diatomacæ, and 282 in November, chiefly Diatomacæ.



## BOSTON.

SUDBURY RIVER SUPPLY.—*Chemical Examination of Water from Reservoir No. 2, Framingham.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|--------------------|-------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.         | Sediment.         | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                    |                   |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 9840    | 1893.<br>Jan. 2     | V. slight.         | Slight.           | 1.30   | 6.10                    | 2.60              | .0014    | .0234       | .0210      | .0024      | .40       | .0050       | .0001     | 1.3067           | 1.8       |
| 9962    | Feb. 1              | V. slight.         | V. slight.        | 1.15   | 5.75                    | 2.60              | .0046    | .0212       | .0188      | .0024      | .31       | .0120       | .0000     | 1.0183           | 1.7       |
| 10067   | Mar. 1              | V. slight.         | Cons.             | 1.00   | 4.40                    | 1.90              | .0010    | .0212       | .0192      | .0020      | .32       | .0100       | .0000     | .8496            | 1.6       |
| 10204   | Apr. 3              | Slight,<br>clayey. | Cons.             | 0.70   | 3.20                    | 1.15              | .0004    | .0146       | .0128      | .0018      | .20       | .0120       | .0000     | .5876            | 0.8       |
| 10342   | May 1               | Slight.            | Slight.           | 1.25   | 3.20                    | 1.45              | .0010    | .0198       | .0178      | .0020      | .26       | .0070       | .0002     | .7665            | 0.8       |
| 10466   | June 1              | Distinct.          | Cons.,<br>earthy. | 1.30   | 3.55                    | 1.65              | .0004    | .0238       | .0198      | .0040      | .25       | .0100       | .0001     | 1.0387           | 0.8       |
| 10590   | July 5              | Slight.            | Slight.           | 1.15   | 3.95                    | 1.90              | .0000    | .0200       | .0232      | .0028      | .24       | .0030       | .0001     | .7738            | 1.1       |
| 10720   | Aug. 3              | Decided.           | Cons.             | 0.80   | 4.25                    | 2.25              | .0000    | .0270       | .0228      | .0042      | .30       | .0000       | .0001     | .5994            | 1.3       |
| 10956   | Sept. 1             | Distinct.          | Slight.           | 0.70   | 3.85                    | 1.80              | .0004    | .0202       | .0160      | .0042      | .25       | .0000       | .0000     | .6399            | 1.1       |
| 11125   | Oct. 2              | Distinct.          | Cons.             | 0.53   | 3.75                    | 1.50              | .0000    | .0186       | .0150      | .0036      | .26       | .0030       | .0000     | .5313            | 1.1       |
| 11276   | Nov. 1              | Slight.            | Slight.           | 0.90   | 4.05                    | 1.35              | .0010    | .0238       | .0210      | .0028      | .43       | .0030       | .0003     | .7000            | 1.1       |
| 11437   | Dec. 4              | Slight,<br>clayey. | V. slight.        | 0.95   | 5.30                    | 2.20              | .0012    | .0234       | .0206      | .0028      | .44       | .0000       | .0003     | .9321            | 1.6       |
| Av      | .....               | .....              | .....             | 0.98   | 4.28                    | 1.86              | .0010    | .0219       | .0190      | .0029      | .31       | .0054       | .0001     | .8120            | 1.2       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 1.09 | 4.94 | 1.87 | .0016 | .0335 | -     | -     | .34 | .0048 | -     | -     | -   |
| - | 1888  | - | - | 1.08 | 4.63 | 2.01 | .0005 | .0300 | -     | -     | .30 | .0102 | .0001 | -     | -   |
| - | 1889  | - | - | 1.04 | 3.42 | 1.26 | .0015 | .0296 | .0252 | .0044 | .29 | .0075 | .0002 | -     | -   |
| - | 1890  | - | - | 0.77 | 4.58 | 1.83 | .0010 | .0235 | .0191 | .0044 | .28 | .0128 | .0001 | -     | 1.7 |
| - | 1891  | - | - | 0.72 | 4.02 | 1.68 | .0004 | .0220 | .0194 | .0036 | .24 | .0105 | .0001 | -     | 1.0 |
| - | 1892  | - | - | 0.89 | 4.35 | 1.92 | .0004 | .0231 | .0192 | .0039 | .29 | .0082 | .0001 | -     | 1.3 |
| - | 1893  | - | - | 0.98 | 4.28 | 1.86 | .0010 | .0219 | .0190 | .0029 | .31 | .0054 | .0001 | .8120 | 1.2 |

\* June to December.

NOTE to analyses of 1893; Iron, .0139. Odor, generally distinctly vegetable, occasionally unpleasant, becoming somewhat stronger on heating. — The samples were collected from the reservoir near the gate-house, at a depth of eight feet beneath the surface. For monthly record of height of water in this reservoir see table at end of Boston analyses.

BOSTON.

SUDBURY RIVER SUPPLY.—*Microscopical Examination of Water from Reservoir No. 2, Framingham.*

[Number of organisms per cubic centimeter.]

|                               | 1893. |      |       |       |       |       |       |       |       |       |       |       |
|-------------------------------|-------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                               | Jan.  | Feb. | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, .         | 3     | 2    | 3     | 4     | 2     | 2     | 6     | 4     | 2     | 3     | 2     | 6     |
| Number of sample, .           | 9840  | 9962 | 10067 | 10204 | 10342 | 10466 | 10590 | 10720 | 10956 | 11125 | 11276 | 11437 |
| PLANTS.                       |       |      |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . .               | 1     | 4    | 3     | 9     | 275   | 28    | 81    | 443   | 32    | 5     | 121   | 23    |
| Cyclotella, . . .             | 0     | 0    | pr.   | 1     | pr.   | 16    | 80    | 360   | 30    | 0     | 36    | 1     |
| Diatoma, . . . .              | 0     | 0    | 0     | 0     | 0     | pr.   | 0     | 2     | 2     | 0     | 44    | 0     |
| Melosira, . . . .             | 0     | 0    | 0     | 0     | 9     | 3     | 0     | 17    | 0     | 2     | 1     | 0     |
| Navicula, . . . .             | 0     | 0    | 0     | 3     | 3     | 1     | 0     | 0     | 0     | 2     | 0     | 4     |
| Synedra, . . . .              | 1     | 1    | 3     | 3     | 252   | 4     | 1     | 60    | pr.   | 1     | 34    | 20    |
| Tabellaria, . . .             | 0     | 3    | 0     | 2     | 11    | 4     | 0     | 4     | 0     | 0     | 6     | 4     |
| Cyanophyceæ, . .              | 0     | 0    | 0     | 0     | pr.   | 0     | 0     | 48    | 45    | 0     | 0     | 0     |
| Anabæna, . . . .              | 0     | 0    | 0     | 0     | pr.   | 0     | 0     | 28    | 25    | 0     | 0     | 0     |
| Anabæna spores, .             | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 20    | 0     | 0     | 0     |
| Microcystis, . .              | 0     | 0    | 0     | 0     | pr.   | 0     | 0     | 20    | 0     | 0     | 0     | 0     |
| Algæ, . . . . .               | 0     | 0    | 0     | 0     | 3     | 2     | 31    | 295   | 88    | 111   | 4     | 0     |
| Cosmarium, . . .              | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 35    | 0     | 0     |
| Gleocystis, . . .             | 0     | 0    | 0     | 0     | 0     | 0     | 22    | 0     | 0     | 0     | 0     | 0     |
| Protococcus, . .              | 0     | 0    | 0     | 0     | 2     | 2     | 6     | 284   | 25    | 0     | 2     | 0     |
| Raphidium, . . .              | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 5     | 60    | 0     | 2     | 0     |
| Scenedesmus, . .              | 0     | 0    | 0     | 0     | 0     | pr.   | 2     | 2     | 0     | 76    | pr.   | 0     |
| Staurostrum, . .              | 0     | 0    | 0     | 0     | 1     | pr.   | 1     | 3     | 1     | 0     | 0     | 0     |
| Fungi, Crenothrix, .          | pr.   | pr.  | 5     | 2     | 18    | pr.   | 0     | 84    | pr.   | 0     | 12    | 0     |
| ANIMALS.                      |       |      |       |       |       |       |       |       |       |       |       |       |
| Rhizopoda, Actinophrys, . . . | 0     | 0    | 0     | 0     | pr.   | pr.   | 0     | 1     | 0     | 0     | 0     | 1     |
| Infusoria, . . . .            | pr.   | 0    | 0     | 0     | 1     | 18    | 1     | 14    | 0     | 8     | 0     | 1     |
| Monas, . . . . .              | pr.   | 0    | 0     | 0     | 1     | 18    | 0     | 0     | 0     | 1     | 0     | 0     |
| Peridinium, . . .             | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 7     | 0     | 1     |
| Vorticella, . . . .           | 0     | 0    | 0     | 0     | 0     | 0     | 1     | 14    | 0     | 0     | 0     | 0     |
| Vermes, . . . . .             | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | pr.   | 0     | 3     | 0     |
| Polyarthra, . . .             | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | pr.   | 0     | 1     | 0     |
| Rotatorian ova, . .           | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     |
| Miscellaneous, Zoöglæa, .     | 0     | 2    | 28    | 38    | 144   | 22    | 22    | 160   | 26    | 224   | 28    | 40    |
| TOTAL, . . . . .              | 1     | 6    | 36    | 49    | 441   | 70    | 135   | 1,025 | 191   | 348   | 166   | 71    |

## BOSTON.

SUDBURY RIVER SUPPLY.—*Chemical Examination of Water from Walker's Brook Marlborough.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.    |                  |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |            |            |           | Chlorine. | NITROGEN AS |            | Oxygen Consumed. | Hardness. |
|---------|---------------------|----------------|------------------|--------|-------------------------|-------------------|----------|------------|------------|-----------|-----------|-------------|------------|------------------|-----------|
|         |                     | Turbidity.     | Sediment.        | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid |            | Nitrates. |           | Nitrites.   |            |                  |           |
|         |                     |                |                  |        |                         |                   |          | Total.     | Dissolved. |           |           |             | Suspended. |                  |           |
| 9834    | 1893. Jan. 2        | Decided.       | Heavy, gray.     | 0.70   | 9.30                    | 2.70              | .1280    | .0748      | .0274      | .0474     | 1.60      | .1050       | .0060      | -                | 3.9       |
| 9969    | Feb. 6              | Slight.        | Cons.            | 0.50   | 14.05                   | 3.40              | .0520    | .0216      | .0188      | .0028     | 1.96      | .3000       | .0013      | .5037            | 6.1       |
| 10062   | Mar. 1              | Decided.       | Heavy, earthy.   | 0.60   | 14.55                   | 4.35              | .0716    | .0186      | .0168      | .0018     | 2.12      | .1750       | .0020      | .6588            | 6.0       |
| 10197   | Apr. 3              | Slight.        | Slight.          | 0.70   | 11.65                   | 2.90              | .0318    | .0200      | .0182      | .0018     | 1.59      | .3000       | .0015      | .6095            | 3.8       |
| 10350   | May 2               | Thick.         | Decided.         | 0.70   | 17.20                   | 4.90              | .0416    | .0444      | .0314      | .0130     | 1.78      | .2000       | .0028      | .0576            | 4.1       |
| 10475   | June 5              | Slight.        | Cons., brown.    | 0.50   | 13.55                   | 4.35              | .0044    | .0180      | .0156      | .0024     | 2.08      | .2000       | .0015      | .4575            | 5.0       |
| 10607   | July 5              | Distinct.      | Slight.          | 0.05   | 16.80                   | 5.60              | .0030    | .0124      | .0086      | .0038     | 2.83      | .2000       | .0018      | .1971            | 5.8       |
| 10738   | Aug. 7              | Slight.        | Slight, fibrous. | 0.18   | 15.00                   | 4.25              | .0014    | .0150      | .0126      | .0024     | 1.97      | .2000       | .0018      | .1702            | 5.3       |
| 10964   | Sept. 5             | Slight.        | Slight, brown.   | 0.05   | 14.90                   | 3.70              | .0000    | .0128      | .0100      | .0028     | 1.78      | .1600       | .0002      | .1680            | 6.1       |
| 11131   | Oct. 2              | V. slight.     | V. slight.       | 0.10   | 11.00                   | 3.20              | .0000    | .0144      | .0120      | .0024     | 1.66      | .1000       | .0004      | .2079            | 4.3       |
| 11272   | Nov. 1              | Slight, milky. | V. slight.       | 0.42   | 18.10                   | 4.20              | .0042    | .0184      | .0160      | .0024     | 2.57      | .1440       | .0020      | .4600            | 7.7       |
| 11432   | Dec. 4              | Decided.       | Cons.            | 0.07   | 12.50                   | 3.70              | .0664    | .0378      | .0284      | .0094     | 1.58      | .1700       | .0024      | .7995            | 4.0       |
| Av.     | 1893...             | .....          | .....            | 0.38   | 14.05                   | 3.94              | .0337    | .0257      | .0180      | .0077     | 1.96      | .1878       | .0020      | .3927            | 5.2       |
| Av.     | 1892...             | .....          | .....            | 0.49   | 16.84                   | 4.35              | .0307    | .0274      | .0225      | .0048     | 2.58      | .2975       | .0037      | -                | 5.7       |

Iron, .0278. Odor, generally distinctly mouldy or musty, occasionally offensive. On heating, the odor becomes somewhat stronger. — The samples were collected from the brook at the first road bridge below Maple Street, about a mile south of the centre of the city of Marlborough.

This series of analyses is being made in order to determine to what extent the pollution of the brook will be diminished by the introduction of a sewerage system into the city of Marlborough. The system was put in operation in the latter part of 1891.

## BOSTON.

SUDBURY RIVER SUPPLY.—*Chemical Examination of Water from Stony Brook, at Upper End of Reservoir No. 3, Southborough.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hard-<br>ness. |
|---------|---------------------|-------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|----------------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |                |
|         |                     |             |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |                |
| 9841    | 1893.<br>Jan. 2     | Decided.    | Cons.             | 0.90   | 6.20                            | 2.40                 | .0010    | .0344       | .0274      | .0070           | .40       | .0100          | .0003     | 1.1023           | 2.3            |
| 9903    | Feb. 1              | V. slight.  | V. slight.        | 0.90   | 7.15                            | 2.40                 | .0116    | .0186       | .0162      | .0024           | .52       | .0350          | .0002     | .8030            | 2.6            |
| 10068   | Mar. 1              | V. slight.  | V. slight.        | 1.20   | 6.05                            | 2.50                 | .0084    | .0228       | .0198      | .0030           | .46       | .0300          | .0001     | .8928            | 2.2            |
| 10203   | Apr. 3              | Slight.     | Slight.           | 1.00   | 4.10                            | 1.35                 | .0005    | .0220       | .0196      | .0024           | .24       | .0100          | .0002     | .7957            | 0.9            |
| 10343   | May 1               | V. slight.  | Slight.           | 1.30   | 4.90                            | 2.20                 | .0012    | .0296       | .0236      | .0060           | .39       | .0200          | .0002     | .9818            | 1.4            |
| 10467   | June 1              | Distinct.   | Cons.,<br>earthy. | 1.70   | 5.20                            | 2.70                 | .0018    | .0320       | .0294      | .0026           | .34       | .0120          | .0001     | 1.1362           | 1.4            |
| 10591   | July 5              | V. slight.  | V. slight.        | 1.30   | 5.65                            | 2.60                 | .0034    | .0356       | .0334      | .0022           | .33       | .0070          | .0000     | 1.0191           | 1.8            |
| 10721   | Aug. 3              | V. slight.  | Slight.           | 0.55   | 5.70                            | 2.15                 | .0016    | .0252       | .0210      | .0042           | .58       | .0030          | .0001     | .4440            | 1.9            |
| 10957   | Sept. 1             | V. slight.  | V. slight.        | 0.50   | 5.90                            | 2.20                 | .0014    | .0256       | .0208      | .0048           | .51       | .0030          | .0001     | .5490            | 2.1            |
| 11126   | Oct. 2              | V. slight.  | Slight.           | 0.38   | 5.95                            | 1.70                 | .0000    | .0208       | .0184      | .0024           | .71       | .0000          | .0000     | .3850            | 2.2            |
| 11277   | Nov. 1              | Slight.     | V. slight.        | 0.95   | 8.10                            | 2.70                 | .0012    | .0368       | .0330      | .0038           | .89       | .0070          | .0004     | .9880            | 2.3            |
| 11438   | Dec. 4              | V. slight.  | V. slight.        | 0.70   | 7.40                            | 2.30                 | .0008    | .0246       | .0224      | .0022           | .66       | .0150          | .0003     | .8073            | 2.6            |
| Av.     | .....               | .....       | .....             | 0.95   | 6.03                            | 2.27                 | .0027    | .0273       | .0237      | .0036           | .50       | .0127          | .0002     | .8254            | 2.0            |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 0.97 | 7.74 | 2.36 | .0029 | .0355 | -     | -     | .74 | .0152 | -     | -     | -   |
| - | 1888  | - | - | 1.16 | 6.25 | 2.17 | .0039 | .0312 | -     | -     | .51 | .0303 | .0004 | -     | -   |
| - | 1889  | - | - | 1.11 | 5.04 | 1.76 | .0061 | .0308 | .0280 | .0028 | .50 | .0275 | .0005 | -     | -   |
| - | 1890  | - | - | 0.72 | 7.31 | 2.12 | .0033 | .0257 | .0225 | .0032 | .56 | .0262 | .0003 | -     | 2.4 |
| - | 1891  | - | - | 0.86 | 6.15 | 2.24 | .0047 | .0291 | .0256 | .0035 | .59 | .0226 | .0003 | -     | 2.0 |
| - | 1892  | - | - | 0.96 | 6.19 | 2.35 | .0015 | .0291 | .0252 | .0039 | .49 | .0202 | .0002 | -     | 1.9 |
| - | 1893  | - | - | 0.95 | 6.03 | 2.27 | .0027 | .0273 | .0237 | .0036 | .50 | .0127 | .0002 | .8254 | 2.0 |

\* June to December.

NOTE to analyses of 1893; Iron, .0172. Odor, generally distinctly vegetable, frequently mouldy or unpleasant; on heating, the odor is stronger and frequently grassy.—The samples were collected from the brook about 50 feet below the first road above Reservoir No. 3, at a depth of one foot beneath the surface.

*Microscopical Examination.*

Average number of organisms in 1893, 123 per cubic centimeter. In September, when the organisms were most abundant, 302 were found, nearly all of which were *Crenothrix*.

## BOSTON.

**SUDBURY RIVER SUPPLY.—Chemical Examination of Water from Reservoir  
No. 3, Framingham.**

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.          |                  |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|----------------------|------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.           | Sediment.        | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                      |                  |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 9842    | 1893.<br>Jan. 2     | Slight.              | Slight.          | 1.00   | 6.40                            | 2.80                 | .0024    | .0242       | .0220      | .0022           | .49       | .0050          | .0001     | .9271            | 2.2       |
| 9964    | Feb. 1              | Slight.              | Slight.          | 0.90   | 6.15                            | 2.15                 | .0084    | .0240       | .0192      | .0048           | .50       | .0200          | .0001     | .8796            | 2.2       |
| 10060   | Mar. 1              | V. slight.           | Cons.            | 0.90   | 4.20                            | 1.85                 | .0132    | .0228       | .0204      | .0024           | .29       | .0200          | .0001     | .7920            | 1.7       |
| 10202   | Apr. 3              | Distinct,<br>clayey. | Cons.            | 0.65   | 3.95                            | 1.30                 | .0056    | .0194       | .0140      | .0044           | .20       | .0230          | .0001     | .6095            | 1.4       |
| 10344   | May 1               | Slight.              | Slight.          | 1.00   | 4.00                            | 1.95                 | .0008    | .0206       | .0168      | .0038           | .32       | .0200          | .0002     | .7409            | 1.3       |
| 10468   | June 1              | Distinct.            | Cons.            | 1.20   | 4.40                            | 1.90                 | .0004    | .0266       | .0244      | .0022           | .30       | .0090          | .0002     | .9525            | 1.4       |
| 10592   | July 5              | Distinct.            | Slight.          | 1.20   | 5.00                            | 2.05                 | .0000    | .0274       | .0246      | .0028           | .26       | .0050          | .0001     | .9243            | 1.3       |
| 10722   | Aug. 3              | Decided,<br>green.   | Cons.,<br>brown. | 0.85   | 4.95                            | 2.40                 | .0000    | .0284       | .0204      | .0080           | .36       | .0050          | .0000     | .6660            | 1.9       |
| 10958   | Sept. 1             | Decided.             | Slight.          | 0.85   | 4.25                            | 1.80                 | .0000    | .0296       | .0214      | .0082           | .33       | .0000          | .0000     | .7189            | 1.8       |
| 11127   | Oct. 2              | Decided.             | Cons.            | 0.70   | 5.25                            | 2.75                 | .0004    | .0346       | .0232      | .0114           | .37       | .0000          | .0000     | .6314            | 1.6       |
| 11278   | Nov. 1              | Distinct.            | Cons.            | 0.90   | 5.30                            | 2.25                 | .0012    | .0308       | .0212      | .0096           | .49       | .0030          | .0004     | .7320            | 1.8       |
| 11439   | Dec. 4              | Slight,<br>clayey.   | Slight.          | 0.65   | 5.80                            | 2.05                 | .0014    | .0232       | .0202      | .0030           | .57       | .0050          | .0001     | .6435            | 2.3       |
| Av.     | .....               | .....                | .....            | 0.90   | 4.97                            | 2.10                 | .0028    | .0259       | .0207      | .0052           | .37       | .0100          | .0001     | .7681            | 1.7       |

*Average of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 0.91 | 5.48 | 2.02 | .0073 | .0318 | -     | -     | .43 | .0170 | -     | -     | -   |
| - | 1888  | - | - | 0.98 | 4.98 | 1.79 | .0038 | .0288 | -     | -     | .40 | .0218 | .0003 | -     | -   |
| - | 1889  | - | - | 0.84 | 4.39 | 1.50 | .0042 | .0306 | .0254 | .0052 | .42 | .0182 | .0003 | -     | -   |
| - | 1890  | - | - | 0.62 | 5.40 | 1.84 | .0020 | .0238 | .0197 | .0041 | .40 | .0229 | .0002 | -     | 2.0 |
| - | 1891  | - | - | 0.60 | 4.75 | 1.66 | .0032 | .0242 | .0200 | .0042 | .38 | .0190 | .0002 | -     | 1.7 |
| - | 1892  | - | - | 0.72 | 5.17 | 1.97 | .0024 | .0254 | .0219 | .0035 | .40 | .0211 | .0001 | -     | 1.8 |
| - | 1893  | - | - | 0.90 | 4.97 | 2.10 | .0028 | .0259 | .0207 | .0052 | .37 | .0100 | .0001 | .7681 | 1.7 |

\* June to December.

**NOTE** to analyses of 1893; Iron, .0178. Odor, generally distinctly vegetable. On heating the odor is stronger and frequently unpleasant or disagreeable.—The samples were collected from the reservoir near the gate-house at a depth of eight feet beneath the surface. For monthly record of height of water in this reservoir see table at end of Boston analyses.

BOSTON.

SUDBURY RIVER SUPPLY. — *Microscopical Examination of Water from Reservoir No. 3, Framingham.*

[Number of organisms per cubic centimeter.]

|                               | 1893. |      |       |       |       |       |       |       |       |       |       |       |
|-------------------------------|-------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                               | Jan.  | Feb. | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .     | 3     | 2    | 3     | 4     | 2     | 2     | 6     | 4     | 2     | 3     | 2     | 6     |
| Number of sample, . . .       | 9842  | 9964 | 10069 | 10202 | 10344 | 10468 | 10592 | 10722 | 10958 | 11127 | 11278 | 11439 |
| PLANTS.                       |       |      |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .             | 630   | pr.  | 24    | 13    | 623   | 278   | 51    | 818   | 37    | 1,516 | 957   | 212   |
| Asterionella, . . .           | 35    | 0    | pr.   | 1     | 450   | 60    | 0     | 0     | 15    | 672   | 480   | 100   |
| Cyclotella, . . .             | 0     | pr.  | 0     | 0     | 1     | 2     | 48    | 800   | 1     | 0     | 44    | 2     |
| Diatoma, . . .                | 0     | pr.  | 0     | 0     | 10    | 4     | 0     | 3     | 0     | 0     | 56    | 0     |
| Fragilaria, . . .             | 0     | 0    | 0     | 0     | 10    | 6     | 0     | 0     | 0     | 0     | 0     | 0     |
| Melosira, . . .               | 1     | 0    | 0     | 2     | 4     | 28    | 0     | 3     | 0     | 0     | 25    | 18    |
| Synedra, . . .                | 2     | 0    | 2     | 4     | 116   | 74    | 2     | 3     | 1     | 0     | 280   | 80    |
| Tabellaria, . . .             | 592   | 0    | 22    | 6     | 32    | 104   | 1     | 9     | 20    | 844   | 72    | 12    |
| Cyanophyceæ, . . .            | 0     | 0    | 0     | 0     | 0     | 0     | 17    | 74    | 50    | 0     | 4     | 0     |
| Anabæna, . . .                | 0     | 0    | 0     | 0     | 0     | 0     | 17    | 52    | 0     | 0     | 0     | 0     |
| Clathrocystis, . . .          | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 22    | 50    | 0     | 4     | 0     |
| Algeæ, . . .                  | 3     | 0    | 0     | 0     | 103   | 6     | 71    | 24    | 1     | 18    | 37    | †     |
| Chlorococcus, . . .           | 0     | 0    | 0     | 0     | 1     | 0     | 0     | 5     | 0     | 17    | 1     | 0     |
| Protococcus, . . .            | 0     | 0    | 0     | 0     | 0     | 5     | 64    | 15    | 0     | 0     | 20    | 0     |
| Raphidium, . . .              | 1     | 0    | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 8     | 0     |
| Scenedesmus, . . .            | 2     | 0    | 0     | 0     | 80    | 1     | 3     | 0     | 0     | 0     | 5     | 1     |
| Stauroastrum, . . .           | 0     | 0    | 0     | 0     | 22    | 0     | 0     | 2     | 1     | 1     | 0     | 0     |
| Staurogenia, . . .            | 0     | 0    | 0     | 0     | 0     | 0     | 4     | 0     | 0     | 0     | 3     | 0     |
| Fungi, Crenothrix, . . .      | 0     | 0    | 0     | 2     | 0     | 0     | 1     | 0     | 0     | 0     | 3     | 0     |
| ANIMALS.                      |       |      |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . .              | 1     | 0    | 6     | 2     | 3     | 2     | 2     | 25    | 1     | 125   | 109   | 1     |
| Dinobryon, . . .              | 0     | 0    | 5     | 0     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, . . .        | 0     | 0    | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 104   | 1     |
| Monas, . . .                  | 0     | 0    | 0     | 0     | 0     | 1     | 2     | 2     | pr.   | 0     | 0     | 0     |
| Peridinium, . . .             | pr.   | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 124   | 0     | 0     |
| Synura, . . .                 | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     |
| Trachelomonas, . . .          | 1     | 0    | 1     | 0     | 0     | 1     | 0     | 4     | 1     | 1     | 5     | 0     |
| Vorticella, . . .             | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 17    | 0     | 0     | 0     | 0     |
| Vermes, Polyarthra, . . .     | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 7     | 0     |
| Miscellaneous, Zoöglæa, . . . | 82    | 0    | 82    | 64    | 396   | 44    | 2     | 320   | 24    | 432   | 56    | 6     |
| TOTAL, . . .                  | 716   | pr.  | 112   | 91    | 1,125 | 330   | 144   | 1,261 | 113   | 2,091 | 1,173 | 220   |

## BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Reservoir No. 6, Ashland, collected near the Bottom.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13563   | 1895. Jan. 1        | V. slight.  | Slight.        | 0.60   | 3.95                    | 1.80              | .0022    | .0212       | .0186      | .0026      | .41       | .0030       | .0000     | .6506            | 1.4       |
| 13742   | Feb. 4              | V. slight.  | V. slight.     | 0.65   | 4.35                    | 1.90              | .0030    | .0194       | .0178      | .0016      | .48       | .0070       | .0000     | .9085            | 1.4       |
| 13908   | Mar. 4              | V. slight.  | V. slight.     | 0.80   | 5.10                    | 1.90              | .0050    | .0232       | .0218      | .0014      | .47       | .0100       | .0000     | .7407            | 1.7       |
| 14061   | Apr. 1              | Distinct.   | Slight.        | 0.80   | 4.20                    | 1.70              | .0042    | .0202       | .0192      | .0010      | .43       | .0050       | .0001     | .8378            | 1.1       |
| 14231   | May 1               | V. slight.  | Slight.        | 0.90   | 4.15                    | 1.90              | .0036    | .0180       | .0166      | .0014      | .35       | .0120       | .0001     | .7392            | 1.4       |
| 14400   | June 3              | Slight.     | Slight.        | 0.70   | 4.05                    | 1.75              | .0016    | .0182       | .0170      | .0012      | .39       | .0110       | .0000     | .6688            | 1.7       |
| 14567   | July 1              | Slight.     | Slight.        | 0.65   | 4.00                    | 1.80              | .0036    | .0178       | .0160      | .0018      | .38       | .0100       | .0000     | .6731            | 1.1       |
| 14744   | Aug. 1              | Slight.     | Slight.        | 0.65   | 4.65                    | 1.95              | .0014    | .0160       | .0142      | .0018      | .38       | .0070       | .0001     | .6699            | 1.4       |
| 14944   | Sept. 2             | Decided.    | Cons.          | 0.75   | 4.55                    | 2.00              | .0130    | .0218       | .0142      | .0076      | .43       | .0000       | .0003     | .6275            | 1.1       |
| 15283   | Oct. 1              | Distinct.   | Cons., clayey. | 0.40   | 4.20                    | 1.80              | .0000    | .0218       | .0180      | .0038      | .40       | .0030       | .0000     | .5655            | 1.3       |
| 15463   | Nov. 4              | Distinct.   | Slight.        | 1.00   | 4.60                    | 2.35              | .0022    | .0250       | .0232      | .0018      | .44       | .0060       | .0002     | 1.0686           | 1.3       |
| 15648   | Dec. 2              | Distinct.   | Slight.        | 1.15   | 4.20                    | 2.20              | .0038    | .0224       | .0212      | .0012      | .36       | .0030       | .0000     | 1.0374           | 0.9       |
| Av.     | 1895                | .....       | .....          | 0.75   | 4.33                    | 1.94              | .0036    | .0204       | .0181      | .0023      | .41       | .0064       | .0001     | .7656            | 1.3       |
| Av.     | 1894*               | .....       | .....          | 1.01   | 4.08                    | 1.73              | .0082    | .0175       | .0149      | .0026      | .38       | .0026       | .0004     | .6724            | 1.2       |

\* April to December.

NOTE to analyses of 1895: Odor, generally distinctly vegetable and occasionally unpleasant. The iron was determined in seven samples, the average amount in parts per 100,000 being .0216. — The samples were collected from the reservoir near the dam.

BOSTON.

COCHITUATE SUPPLY.—*Microscopical Examination of Water from Lake Cochituate, in Wayland.*

[Number of organisms per cubic centimeter.]

|                               | 1893. |      |       |       |       |       |       |       |       |       |       |       |
|-------------------------------|-------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                               | Jan.  | Feb. | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .     | 3     | 2    | 3     | 4     | 2     | 2     | 6     | 4     | 2     | 3     | 2     | 6     |
| Number of sample, . . .       | 9843  | 9965 | 10070 | 10205 | 10345 | 10469 | 10593 | 10723 | 10959 | 11128 | 11279 | 11440 |
| PLANTS.                       |       |      |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .             | 807   | 50   | 34    | 131   | 1,274 | 1,427 | 202   | 0     | 37    | 44    | 192   | 948   |
| Asterionella, . . .           | 518   | 17   | 4     | 32    | 594   | 570   | 0     | 0     | 22    | 24    | 41    | 172   |
| Cyclotella, . . .             | 92    | 22   | 11    | 26    | 74    | 560   | 0     | 0     | 1     | 0     | 17    | 48    |
| Fragilaria, . . .             | 0     | 0    | 0     | 0     | 13    | 0     | 0     | 0     | 0     | 16    | 20    | 0     |
| Melosira, . . .               | 180   | 11   | 18    | 72    | 494   | 10    | 0     | 0     | 0     | 4     | 18    | 280   |
| Stephanodiscus, . . .         | 8     | 0    | 0     | 0     | 0     | 0     | 6     | 0     | 0     | 0     | 0     | 7     |
| Synedra, . . .                | 0     | 0    | 1     | 1     | 98    | 11    | 0     | 0     | 9     | 0     | 0     | 1     |
| Tabellaria, . . .             | 9     | 0    | 0     | pr.   | 1     | 276   | 196   | 0     | 5     | 0     | 96    | 440   |
| Cyanophyceæ, . . .            | 106   | 9    | 0     | 0     | 0     | 23    | 23    | 2     | 21    | 0     | 60    | 0     |
| Anabæna, . . .                | 106   | 0    | 0     | 0     | 0     | 20    | 21    | 0     | 3     | 0     | 22    | 0     |
| Clathrocystis, . . .          | pr.   | 0    | 0     | 0     | 0     | 3     | 2     | 0     | 6     | 0     | pr.   | 0     |
| Microcystis, . . .            | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 2     | 12    | 0     | 38    | 0     |
| Algæ, . . .                   | 18    | 0    | 4     | 0     | 0     | 26    | 64    | 24    | 10    | 52    | 76    | 30    |
| Chlorococcus, . . .           | 2     | 0    | 0     | 0     | 0     | 7     | 0     | 0     | 2     | 52    | 0     | 0     |
| Hyalotheca, . . .             | 12    | 0    | 4     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Protococcus, . . .            | 4     | 0    | 0     | 0     | 0     | 19    | 64    | 20    | 6     | 0     | 76    | 30    |
| Staurogenia, . . .            | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 4     | 2     | 0     | 0     | 0     |
| Fungi, Crenothrix, . . .      | 0     | 0    | pr.   | 1     | 0     | 0     | 0     | 0     | 0     | 3     | pr.   | 1     |
| ANIMALS.                      |       |      |       |       |       |       |       |       |       |       |       |       |
| Rhizopoda, Actinophrys, . . . | 2     | pr.  | 1     | pr.   | 1     | 1     | 1     | 1     | pr.   | 0     | 1     | 0     |
| Infusoria, . . .              | 3     | 6    | 3     | pr.   | 24    | 85    | 2     | 0     | 0     | 2     | 70    | 6     |
| Dinobryon, . . .              | 0     | 0    | 0     | 0     | 5     | 42    | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, . . .        | 0     | 0    | 2     | 0     | 7     | 42    | 0     | 0     | 0     | 0     | 70    | 6     |
| Peridinium, . . .             | 1     | 2    | 0     | 0     | 4     | 0     | 0     | 0     | 0     | 2     | pr.   | 0     |
| Synura, . . .                 | 0     | 0    | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     |
| Trachelomonas, . . .          | 2     | 4    | 1     | pr.   | 2     | 1     | pr.   | 0     | 0     | 0     | 0     | 0     |
| Vorticella, . . .             | 0     | 0    | 0     | 0     | 6     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Crustacea, Cyclops, . . .     | .04   | .04  | 0     | 0     | .02   | .02   | 0     | 0     | 0     | 0     | 0     | 0     |
| Miscellaneous.                |       |      |       |       |       |       |       |       |       |       |       |       |
| Acarina, . . .                | 88    | 2    | 7     | 168   | 508   | .05   | 7     | 4     | 24    | 88    | 0     | 60    |
| Zoöglæa, . . .                | 0     | 0    | 0     | 0     | 0     | .05   | 0     | 0     | 0     | .02   | 0     | 0     |
| Zoöglæa, . . .                | 88    | 2    | 7     | 168   | 508   | 0     | 7     | 4     | 24    | 88    | 0     | 60    |
| TOTAL, . . .                  | 1,024 | 58   | 49    | 300   | 1,807 | 1,562 | 299   | 31    | 92    | 189   | 399   | 1,045 |



## BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Cold Spring Brook, at Head of Reservoir No. 4, Ashland.*

[Parts per 100,000]

| Number.  | Date of Collection | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |        |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|----------|--------------------|-------------|------------|--------|-------------------------|-------------------|----------|--------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|          |                    | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Total. | Dissolved. | Suspended. |           | Nitrates.   | Nitrites. |                  |           |
| 13565    | 1895. Jan. 1       | V. slight.  | V. slight. | 1.50   | 5.35                    | 2.45              | .0008    | .0260  | .0240      | .0020      | .34       | .0030       | .0000     | 1.3800           | 1.7       |
| 13748    | Feb. 4             | V. slight.  | Slight.    | 1.30   | 5.10                    | 2.25              | .0028    | .0260  | .0228      | .0032      | .35       | .0070       | .0000     | 1.3825           | 1.1       |
| 13909    | Mar. 4             | V. slight.  | Slight.    | 1.05   | 4.55                    | 1.80              | .0002    | .0232  | .0220      | .0012      | .33       | .0070       | .0000     | .9610            | 1.1       |
| 14062    | Apr. 1             | Slight.     | V. slight. | 1.10   | 3.70                    | 2.25              | .0002    | .0258  | .0230      | .0028      | .36       | .0030       | .0000     | .9086            | 0.5       |
| 14220    | May 1              | V. slight.  | V. slight. | 1.50   | 4.60                    | 2.75              | .0000    | .0340  | .0294      | .0046      | .36       | .0020       | .0001     | 1.2320           | 1.3       |
| 14402    | June 3             | Distinct.   | Slight.    | 1.30   | 4.20                    | 2.30              | .0012    | .0300  | .0282      | .0018      | .27       | .0030       | .0001     | 1.0830           | 0.9       |
| 14568    | July 1             | Slight.     | Slight.    | 0.90   | 3.85                    | 1.95              | .0004    | .0276  | .0252      | .0024      | .31       | .0000       | .0000     | .8469            | 1.1       |
| 14745    | Aug. 1             | Slight.     | Slight.    | 0.90   | 5.45                    | 2.65              | .0000    | .0292  | .0284      | .0008      | .32       | .0070       | .0000     | 1.0702           | 1.6       |
| 14949    | Sept. 3            | V. slight.  | Slight.    | 0.70   | 4.35                    | 2.15              | .0004    | .0214  | .0198      | .0016      | .34       | .0030       | .0000     | .6006            | 1.2       |
| 15284    | Oct. 1             | Distinct.   | Slight.    | 0.50   | 3.55                    | 1.45              | .0012    | .0250  | .0202      | .0048      | .31       | .0030       | .0000     | .5616            | 1.1       |
| 15464    | Nov. 4             | V. slight.  | V. slight. | 1.85   | 6.90                    | 4.40              | .0000    | .0446  | .0426      | .0020      | .32       | .0030       | .0001     | 2.3244           | 1.6       |
| 15649    | Dec. 2             | V. slight.  | V. slight. | 1.70   | 4.80                    | 2.95              | .0006    | .0292  | .0274      | .0018      | .21       | .0000       | .0000     | 1.5444           | 0.9       |
| Av. .... | .....              | .....       | .....      | 1.19   | 4.70                    | 2.45              | .0006    | .0285  | .0261      | .0024      | .32       | .0034       | .0000     | 1.1584           | 1.2       |

*Averages by Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |        |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|--------|-----|
| - | 1899* | - | - | 2.24 | -    | -    | .0026 | .0410 | .0385 | .0025 | .28 | .0066 | .0001 | -      | -   |
| - | 1890  | - | - | 0.91 | 4.49 | 2.01 | .0011 | .0243 | .0210 | .0033 | .24 | .0090 | .0001 | -      | 1.5 |
| - | 1891  | - | - | 1.30 | 4.87 | 2.30 | .0009 | .0297 | .0282 | .0035 | .23 | .0087 | .0001 | -      | 1.3 |
| - | 1892  | - | - | 1.44 | 5.15 | 2.57 | .0008 | .0308 | .0266 | .0042 | .25 | .0068 | .0001 | -      | 1.2 |
| - | 1893  | - | - | 1.23 | 4.52 | 2.16 | .0013 | .0248 | .0212 | .0036 | .26 | .0031 | .0001 | .9706  | 1.3 |
| - | 1894  | - | - | 1.44 | 4.94 | 2.42 | .0007 | .0237 | .0214 | .0023 | .31 | .0043 | .0000 | 1.1962 | 1.2 |
| - | 1895  | - | - | 1.19 | 4.70 | 2.45 | .0006 | .0285 | .0261 | .0024 | .32 | .0034 | .0000 | 1.1584 | 1.2 |

\* June to December.

NOTE to analyses of 1895: Odor, vegetable. — The samples were collected from the brook at its entrance into Reservoir No. 4.

*Microscopical Examination.*

The average number of organisms per cubic centimeter found in these samples was 68.

## BOSTON.

COCHITUATE WORKS.—*Microscopical Examination of Water from a Faucet at the Massachusetts Institute of Technology, Boston.*

[Number of organisms per cubic centimeter.]

|                           | 1892. |      |       |       |       |       |       |       |       |       |       |       |
|---------------------------|-------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                           | Jan.  | Feb. | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, .     | 3     | 2    | 3     | 4     | 2     | 2     | 6     | 4     | 5     | 3     | 2     | 6     |
| Number of sample, .       | 9844  | 9966 | 10071 | 10207 | 10346 | 10470 | 10594 | 10724 | 10960 | 11129 | 11280 | 11441 |
| PLANTS.                   |       |      |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . .           | 226   | 11   | 10    | 18    | 435   | 80    | 158   | 237   | 140   | 208   | 347   | 117   |
| Asterionella, . .         | 44    | 4    | 2     | 4     | 246   | 22    | 0     | 0     | 8     | 35    | 60    | 36    |
| Cyclotella, . .           | pr.   | 7    | 1     | 2     | 9     | 16    | 26    | 4     | 4     | 0     | 16    | 7     |
| Fragilaria, . .           | 0     | 0    | 0     | 0     | 0     | 23    | 0     | 0     | 0     | 15    | 5     | 0     |
| Melosira, . .             | 4     | 0    | 4     | 6     | 90    | 2     | 0     | 0     | 0     | 10    | 6     | 0     |
| Synedra, . .              | 0     | pr.  | 1     | 2     | 58    | 2     | 0     | 1     | 0     | 0     | 0     | 2     |
| Tabellaria, . .           | 178   | 0    | 2     | 4     | 32    | 15    | 132   | 232   | 128   | 148   | 260   | 72    |
| Cyanophyceæ, . .          | 0     | 0    | 0     | 0     | 0     | 0     | 1     | 7     | 1     | 0     | 15    | 0     |
| Clathrocystis, . .        | 0     | 0    | 0     | 0     | 0     | 0     | 1     | 6     | 0     | 0     | 3     | 0     |
| Microcystis, . .          | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 1     | 1     | 0     | 12    | 0     |
| Algæ, . . . .             | 0     | 0    | pr.   | 0     | 1     | 10    | 0     | 5     | 26    | 7     | 9     | 0     |
| Chlorococcus, . .         | 0     | 0    | 0     | 0     | 1     | pr.   | 0     | 0     | 5     | 0     | 0     | 0     |
| Protococcus, . .          | 0     | 0    | 0     | 0     | 0     | 10    | 0     | 5     | 5     | 0     | 5     | 0     |
| Raphidium, . .            | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 16    | 0     | 4     | 0     |
| Scenedesmus, . .          | 0     | 0    | pr.   | 0     | 0     | pr.   | 0     | 0     | 0     | 7     | 0     | 0     |
| ANIMALS.                  |       |      |       |       |       |       |       |       |       |       |       |       |
| Rhizopoda, Diffugia, .    | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     |
| Infusoria, . . .          | pr.   | 8    | 2     | 0     | 1     | 0     | 0     | 0     | 5     | 6     | 0     | 0     |
| Dinobryon cases, . .      | 0     | 0    | 1     | 0     | 0     | 0     | 0     | 0     | 4     | 0     | 0     | 0     |
| Peridinium, . .           | pr.   | 8    | 0     | 0     | pr.   | 0     | 0     | 0     | 0     | 5     | 0     | 0     |
| Trachelomonas, . .        | 0     | pr.  | 1     | 0     | 1     | 0     | 0     | 0     | 1     | 1     | 0     | 0     |
| Miscellaneous, Zoöglæa, . | 4     | 0    | 30    | 3     | 20    | 16    | 12    | 36    | 28    | 84    | 5     | 11    |
| TOTAL, . . . .            | 230   | 19   | 42    | 21    | 457   | 106   | 171   | 285   | 200   | 307   | 376   | 128   |

## BOSTON.

MYSTIC SUPPLY. — *Chemical Examination of Water from Mystic Lake.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.          |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|----------------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.           | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                      |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1893.   |                     |                      |                   |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 9847    | Jan. 4              | Slight,<br>brown.    | Slight,<br>brown. | 0.04   | 13.80                           | 1.65                 | .0456    | .0180       | .0152      | .0028           | 2.80      | .0700          | .0012     | .2044            | 5.3       |
| 9971    | Feb. 6              | V. slight.           | Slight.           | 0.08   | 14.50                           | 2.00                 | .0520    | .0234       | .0206      | .0028           | 2.90      | .0800          | .0002     | .2066            | 5.4       |
| 10061   | Mar. 1              | Slight.              | Slight.           | 0.10   | 12.50                           | 2.80                 | .0352    | .0222       | .0188      | .0034           | 2.20      | .0900          | .0005     | .2866            | 4.6       |
| 10198   | Apr. 3              | Distinct,<br>clayey. | Slight.           | 0.20   | 8.30                            | 1.30                 | .0420    | .0252       | .0206      | .0046           | 1.30      | .0600          | .0006     | .4015            | 2.9       |
| 10347   | May 2               | Distinct,<br>brown.  | Cons.,<br>brown.  | 0.08   | 11.05                           | 2.15                 | .0480    | .0176       | .0102      | .0074           | 1.98      | .0350          | .0005     | .2847            | 3.8       |
| 10476   | June 5              | Distinct,<br>green.  | Slight,<br>green. | 0.20   | 10.10                           | 2.35                 | .0146    | .0222       | .0176      | .0046           | 1.92      | .0900          | .0010     | .3525            | 3.4       |
| 10586   | July 5              | Distinct.            | Cons.,<br>green.  | 0.05   | 11.75                           | 2.50                 | .0020    | .0190       | .0140      | .0050           | 2.36      | .0750          | .0020     | .2449            | 3.6       |
| 10731   | Aug. 4              | Distinct.            | Cons.             | 0.10   | 12.50                           | 2.25                 | .0008    | .0294       | .0168      | .0126           | 2.66      | .0200          | .0001     | .2627            | 4.2       |
| 10944   | Sept. 1             | Distinct.            | Slight.           | 0.12   | 12.60                           | 1.60                 | .0004    | .0216       | .0142      | .0074           | 2.68      | .0300          | .0001     | .2449            | 4.2       |
| 11121   | Oct. 1              | V. slight.           | Slight,<br>green. | 0.10   | 15.50                           | 2.50                 | .0006    | .0196       | .0146      | .0050           | 3.19      | .0300          | .0006     | .2156            | 4.9       |
| 11282   | Nov. 1              | Distinct.            | Slight.           | 0.05   | 14.75                           | 2.40                 | .0198    | .0210       | .0144      | .0066           | 3.12      | .0400          | .0016     | .2760            | 5.0       |
| 11431   | Dec. 4              | V. slight.           | V. slight.        | 0.03   | 14.05                           | 2.55                 | .0274    | .0182       | .0136      | .0046           | 2.77      | .0800          | .0005     | .2067            | 5.3       |
| Av.     | .....               | .....                | .....             | 0.10   | 12.62                           | 2.17                 | .0240    | .0215       | .0159      | .0056           | 2.49      | .0583          | .0007     | .2656            | 4.4       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |       |      |       |       |       |       |      |       |       |   |     |
|---|-------|---|---|------|-------|------|-------|-------|-------|-------|------|-------|-------|---|-----|
| - | 1887* | - | - | 0.28 | 10.82 | 1.62 | .0114 | .0266 | -     | -     | 2.06 | .0263 | -     | - | -   |
| - | 1888  | - | - | 0.21 | 10.12 | 1.76 | .0244 | .0267 | -     | -     | 1.94 | .0433 | .0016 | - | -   |
| - | 1889  | - | - | 0.26 | 9.02  | 1.97 | .0211 | .0278 | .0209 | .0069 | 1.67 | .0586 | .0012 | - | -   |
| - | 1890  | - | - | 0.13 | 10.65 | 1.78 | .0197 | .0223 | .0183 | .0040 | 1.57 | .0796 | .0008 | - | 3.7 |
| - | 1891  | - | - | 0.13 | 9.50  | 1.81 | .0186 | .0242 | .0187 | .0055 | 1.58 | .0731 | .0012 | - | 3.5 |
| - | 1892  | - | - | 0.07 | 11.52 | 2.09 | .0185 | .0206 | .0153 | .0053 | 2.22 | .0698 | .0007 | - | 4.1 |
| - | 1893  | - | - | 0.10 | 12.62 | 2.17 | .0240 | .0215 | .0159 | .0056 | 2.49 | .0583 | .0007 | - | 4.4 |

\* June to December.

NOTE to analyses of 1893; Iron, .0040. Odor, generally vegetable and mouldy or disagreeable. — The samples were collected from the lake near the gate-house. For monthly record of height of water in this lake, see table at end of Boston analyses.

BOSTON.

MYSTIC SUPPLY.—*Microscopical Examination of Water from Mystic Lake.*

[Number of organisms per cubic centimeter.]

|                             | 1893. |      |       |       |       |       |       |       |       |       |       |       |
|-----------------------------|-------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                             | Jan.  | Feb. | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .   | 5     | 7    | 2     | 4     | 2     | 6     | 5     | 5     | 2     | 2     | 3     | 4     |
| Number of sample, . . .     | 9847  | 9971 | 10061 | 10198 | 10347 | 10476 | 10586 | 10731 | 10944 | 11121 | 11282 | 11431 |
| PLANTS.                     |       |      |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .           | 345   | 18   | 19    | 3     | 524   | 3,972 | 5,647 | 1,064 | 971   | 499   | 7,841 | 2,406 |
| Asterionella, . . .         | 98    | 6    | 11    | pr.   | 25    | 0     | 0     | 0     | 0     | 0     | 1     | 0     |
| Diatoma, . . .              | 102   | 0    | 0     | 0     | 0     | 0     | 7     | 0     | 0     | 0     | 0     | 0     |
| Fragilaria, . . .           | 66    | 0    | 3     | 0     | 47    | 92    | 160   | 164   | 9     | 464   | 640   | 6     |
| Melosira, . . .             | 0     | 0    | 0     | 1     | 22    | 0     | 0     | 0     | 0     | 3     | 0     | 0     |
| Navicula, . . .             | 3     | 0    | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 0     |
| Synedra, . . .              | 76    | 12   | 4     | 2     | 402   | 3,880 | 5,480 | 900   | 960   | 31    | 7,200 | 2,400 |
| Tabellaria, . . .           | 0     | 0    | 0     | 0     | 28    | 0     | 0     | 0     | 2     | 0     | 0     | 0     |
| Algæ, . . .                 | 124   | 2    | 2     | 0     | 26    | 197   | 183   | 1,487 | 137   | 264   | 930   | 164   |
| Cosmarium, . . .            | 5     | 1    | 0     | 0     | 0     | 0     | 0     | 32    | 2     | pr.   | 28    | 4     |
| Pediastrum, . . .           | 0     | 0    | 0     | 0     | 0     | pr.   | 1     | 3     | 7     | 0     | 2     | 0     |
| Protococcus, . . .          | 0     | 0    | pr.   | 0     | 26    | 28    | 0     | 44    | 0     | 0     | 220   | 9     |
| Raphidium, . . .            | 5     | 0    | 0     | 0     | 0     | pr.   | 0     | 0     | 0     | 0     | 0     | 2     |
| Scenedesmus, . . .          | 114   | 1    | 2     | 0     | 0     | 164   | 180   | 1,360 | 128   | 264   | 680   | 148   |
| Staurostrum, . . .          | pr.   | 0    | 0     | 0     | 0     | 5     | 2     | 48    | 0     | 0     | 0     | 1     |
| Fungi, Crenothrix, . . .    | 1     | 0    | pr.   | 0     | pr.   | 0     | 0     | 0     | 0     | 0     | 20    | 40    |
| ANIMALS.                    |       |      |       |       |       |       |       |       |       |       |       |       |
| Rhizopoda, Diffugia, . .    | 0     | 0    | 0     | 0     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Infusoria, Peridinium, . .  | pr.   | 0    | pr.   | 0     | 0     | 0     | 272   | 2,100 | 0     | 228   | 15    | 0     |
| Vermes, . . .               | 0     | 0    | 0     | 0     | 1     | 0     | 1     | 3     | 1     | 0     | 0     | 0     |
| Anurea, . . .               | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 1     | 1     | 0     | 0     | 0     |
| Monocerca, . . .            | 0     | 0    | 0     | 0     | 1     | 0     | 1     | 0     | 0     | 0     | 0     | 0     |
| Polyarthra, . . .           | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     |
| Miscellaneous, Zoöglæa, . . | 280   | 0    | 244   | 160   | 5     | 36    | 3     | 3     | 760   | 36    | 76    | 8     |
| Total, . . .                | 750   | 20   | 265   | 163   | 550   | 4,205 | 6,106 | 4,657 | 1,809 | 1,027 | 8,882 | 2,618 |

## BOSTON.

MYSTIC SUPPLY.—*Chemical Examination of Water from Mystic Lake, at Various Depths.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |            |            | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|------------|------------|-------------------------|-------------------|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment.  | Color.     | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |             |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                     |            |            |                         |                   |          | Total.      | Dissolved. | Sus-pended. |           |             |           |                  |           |
| 10095   | 1893.<br>Mar. 8     | Distinct,<br>milky. | V. slight. | 0.30       | 11.95                   | 2.25              | .0800    | .0218       | .0192      | .0026       | 2.26      | .0600       | .0005     | .3384            | 4.7       |
| 10096   | Mar. 8              |                     | Slight.    | V. slight. | 0.04                    | 15.30             | 2.80     | .0160       | .0136      | .0118       | .0018     | 3.20        | .0550     | .0001            | .1872     |
| 10097   | Mar. 8              | Slight.             | Slight.    | 0.07       | 16.95                   | 2.80              | .1120    | .0130       | .0118      | .0012       | 3.44      | .0600       | .0003     | .1548            | 6.1       |
| 10098   | Mar. 8              | Distinct,<br>milky. | V. slight. | 0.70       | 17.80                   | -                 | .3840    | .0364       | .0214      | .0150       | 3.40      | .0070       | .0000     | .3168            | 7.9       |

Iron, in the first sample, .0080; in the second, none; in the third, .0020; in the last, .0770.

Odor of the first sample, faintly disagreeable, becoming stronger on heating; of the next two samples, very faint or none; of the last sample, offensive. — The first sample was collected at the surface, and the others in order at depths of 20, 54 and 74 feet respectively beneath the surface.

MYSTIC SUPPLY.—*Microscopical Examination of Water from Mystic Lake, at Various Depths.*

[Number of organisms per cubic centimeter.]

|                                   | 1893.  |        |        |        |
|-----------------------------------|--------|--------|--------|--------|
|                                   | March. | March. | March. | March. |
| Day of examination, . . . . .     | 9      | 9      | 9      | 9      |
| Number of sample, . . . . .       | 10095  | 10096  | 10097  | 10098  |
| <b>PLANTS.</b>                    |        |        |        |        |
| Diatomaceæ, . . . . .             | 0      | 52     | 72     | 98     |
| Asterionella, . . . . .           | 0      | 38     | 60     | 92     |
| Diatoma, . . . . .                | 0      | 0      | 4      | 2      |
| Fragilaria, . . . . .             | 0      | 0      | 1      | 0      |
| Navicula, . . . . .               | 0      | pr.    | 2      | 1      |
| Synedra, . . . . .                | 0      | 14     | 5      | 3      |
| Algae, . . . . .                  | 0      | 0      | pr.    | 7      |
| Protococcus, . . . . .            | 0      | 0      | 0      | 4      |
| Scenedesmus, . . . . .            | 0      | 0      | pr.    | 2      |
| Ulothrix, . . . . .               | 0      | 0      | 0      | 1      |
| Miscellaneous, Zoöglæa, . . . . . | 158    | 178    | 320    | 2,028  |
| TOTAL, . . . . .                  | 158    | 228    | 392    | 2,183  |

## BOSTON.

MYSTIC SUPPLY.—*Chemical Examination of Water from a Faucet in Everett supplied from the Mystic Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 10101   | 1893.<br>Mar. 7     | Slight.     | Slight.   | 0.18   | 13.20                   | 2.50              | .0672    | .0232       | .0212      | .0020      | 2.64      | .0900       | .0002     | .3024            | 5.0       |

Iron, .0100. Odor, offensive. — The sample was collected from a faucet in Everett.

*Microscopical Examination.*

Diatomaceæ, *Asterionella*, 16; *Synedra*, 1. Fungi, *Fungus*, 8. Infusoria, *Vorticella*, 1. Miscellaneous, *Zoëglæa*, 208. Total, 234.

*Table showing the Average Monthly Heights in Feet above Tide-marsh level of the Water in the Lakes and Storage Reservoirs of the Boston Water Works, from which Samples of Water were collected during the Year 1893.*

|                    | Reservoir<br>No. 2.<br>Flash Boards,<br>167.12 | Reservoir<br>No. 3.<br>Stone Crest,<br>175.24 | Reservoir<br>No. 4.<br>Flash Boards,<br>215.21 | Farm Pond.<br>High Water,<br>149.25 | Lake<br>Cochituate<br>High Water,<br>134.36 | Mystic Lake.<br>High Water,<br>7.00 |
|--------------------|------------------------------------------------|-----------------------------------------------|------------------------------------------------|-------------------------------------|---------------------------------------------|-------------------------------------|
| January, . . . .   | 162.95                                         | 169.42                                        | 196.79                                         | 148.78                              | 128.38                                      | 4.64                                |
| February, . . . .  | 164.17                                         | 172.49                                        | 201.05                                         | 149.08                              | 128.71                                      | 4.33                                |
| March, . . . .     | 165.02                                         | 174.17                                        | 210.22                                         | 149.06                              | 131.55                                      | 4.43                                |
| April, . . . .     | 166.20                                         | 175.60                                        | 214.59                                         | 149.42                              | 134.03                                      | 6.22                                |
| May, . . . .       | 166.43                                         | 175.59                                        | 214.66                                         | 149.75                              | 134.41                                      | 6.37                                |
| June, . . . .      | 166.96                                         | 174.79                                        | 215.15                                         | 148.87                              | 133.68                                      | 6.41                                |
| July, . . . .      | 162.92                                         | 171.84                                        | 215.08                                         | 148.60                              | 132.49                                      | 4.52                                |
| August, . . . .    | 161.29                                         | 167.57                                        | 208.63                                         | 148.55                              | 131.21                                      | 2.64                                |
| September, . . . . | 161.86                                         | 167.75                                        | 190.30                                         | 148.42                              | 129.30                                      | 1.80                                |
| October, . . . .   | 158.99                                         | 161.10                                        | 180.38                                         | 148.27                              | 128.24                                      | —0.96                               |
| November, . . . .  | 157.48                                         | 158.69                                        | 172.70                                         | 148.37                              | 128.03                                      | —0.20                               |
| December, . . . .  | 156.55                                         | 162.90                                        | 171.87                                         | 148.63                              | 127.67                                      | 1.19                                |

The reservoirs on Sudbury River were drawn to an unusually low level in 1893. Reservoir No. 2 in December contained 116,500,000 gallons equal to 22 per cent. of its total capacity; Reservoir No. 3 in November contained 62,000,000 gallons equal to 5.6 per cent. of its total capacity; Reservoir No. 4 in December was practically empty, containing only 11,000,000 gallons, equal to less than one per cent. of its total capacity.

## BOSTON.

SUDBURY RIVER SUPPLY.—*Microscopical Examination of Water from Reservoir No. 2, Framingham.*

[Number of organisms per cubic centimeter.]

|                                 | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|---------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                 | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . .     | 2     | 5     | 6     | 3     | 1     | 4     | 2     | 2     | 4     | 2     | 6     | 3     |
| Number of sample, . . . .       | 13568 | 18744 | 13912 | 14065 | 14223 | 14405 | 14560 | 14749 | 14953 | 15287 | 15467 | 15691 |
| <b>PLANTS.</b>                  |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . .             | 16    | 5     | 3     | 11    | 60    | 156   | 469   | 374   | 535   | 236   | 6     | 11    |
| Cyclotella, . . . .             | 0     | 0     | 0     | 0     | 0     | 67    | 456   | 372   | 528   | 216   | 0     | 0     |
| Melosira, . . . .               | 3     | 0     | 0     | 1     | 2     | 0     | 1     | 0     | 0     | 5     | 0     | 0     |
| Navicula, . . . .               | 0     | 0     | 0     | pr.   | 2     | 10    | 3     | 0     | 2     | 2     | 0     | 0     |
| Pinnularia, . . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 2     | 4     | 0     | 0     |
| Synedra, . . . .                | 4     | 4     | 3     | 3     | 48    | 74    | 5     | 2     | 3     | 9     | 5     | 12    |
| Tabellaria, . . . .             | 9     | 1     | 0     | 7     | 8     | 5     | 3     | 0     | 0     | 0     | 1     | 6     |
| Cyanophyceæ, . . . .            | 0     | 0     | 0     | 0     | 0     | 1     | 22    | 3     | 0     | 3     | 0     | 0     |
| Merismopedia, . . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 22    | 0     | 0     | 0     | 0     | 0     |
| Microcystis, . . . .            | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 3     | 0     | 3     | 0     | 0     |
| Algæ, . . . .                   | 0     | 0     | 1     | 0     | 4     | 47    | 148   | 88    | 88    | 114   | 0     | 0     |
| Glæocapsa, . . . .              | 0     | 0     | 0     | 0     | 0     | 0     | 84    | 2     | 0     | 0     | 0     | 0     |
| Protooccus, . . . .             | 0     | 0     | 1     | 0     | 3     | 18    | 61    | 27    | 55    | 108   | 0     | 0     |
| Raphidium, . . . .              | 0     | 0     | 0     | 0     | 0     | 10    | 0     | 20    | 28    | 6     | 0     | 0     |
| Scenedesmus, . . . .            | 0     | 0     | 0     | 0     | 1     | 19    | 3     | 1     | 5     | 0     | 0     | 0     |
| Staurogenia, . . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 38    | 0     | 0     | 0     | 0     |
| Fungi, Crenothrix, . . . .      | 0     | 2     | 4     | 5     | 9     | 0     | 0     | 5     | 1     | 0     | 28    | 24    |
| <b>ANIMALS.</b>                 |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . . .              | 1     | 0     | 0     | 5     | 6     | 0     | 0     | 0     | 0     | 1     | 2     | 2     |
| Codonella, . . . .              | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     |
| Dinobryon cases, . . . .        | 0     | 0     | 0     | 2     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Euglena, . . . .                | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Peridinium, . . . .             | 1     | 0     | 0     | 1     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Trachelomonas, . . . .          | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 2     |
| Miscellaneous, Zoöglæa, . . . . | 0     | 0     | 154   | 16    | 0     | 0     | 0     | 0     | 292   | 180   | 40    | 60    |
| TOTAL, . . . .                  | 17    | 7     | 162   | 37    | 79    | 204   | 639   | 470   | 916   | 514   | 76    | 104   |

## BRADFORD.

to the water are at first so very fine that they communicate to the water a milky appearance which cannot be removed by filtration, and the effect of it is to make the water appear colored as if from dissolved coloring matter. When the oxidation of the iron is complete, a rusty precipitate usually forms and the supernatant or filtered water is again clear and colorless. Any record of turbidity, sediment or color, while the oxidation of the iron is in progress, relates, therefore, to a passing phenomenon, but is nevertheless of interest as showing a condition which the water may assume; these records cannot, however, be considered as indicating the comparative character of the water from month to month, because they depend so largely upon the extent of the oxidation of the iron at the time they were made. The presence of iron affects the determination of the "oxygen consumed," and the results of this determination as given in the tables are in consequence all a little higher than they would otherwise be. A progressive deterioration of this water, as compared with previous years, will be noted. The organic matter, as shown by the albuminoid ammonia, and the product of its decomposition, as shown by the free ammonia, are decidedly on the increase.

*Microscopical Examination of Water from the Wells of the Bradford Water Company.*

[Number of organisms per cubic centimeter.]

|                           | 1893. |       |       |       |       |       |       |       |       |       |       |       |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                           | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, .     | 29    | 17    | 10    | 12    | 10    | 9     | 8     | 10    | 14    | 10    | 10    | 7     |
| Number of sample, .       | 9889  | 10022 | 10103 | 10233 | 10371 | 10496 | 10613 | 10753 | 11012 | 11158 | 11308 | 11453 |
| PLANTS.                   |       |       |       |       |       |       |       |       |       |       |       |       |
| Fungi, Crenothrix, .      | 0     | 0     | 0     | 0     | 0     | pr.   | 0     | 0     | 7     | 1     | 0     | 0     |
| ANIMALS.                  |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . .          | 0     | 0     | 0     | 0     | 0     | 4     | 0     | 1     | 0     | 0     | 0     | 0     |
| Dinobryon cases, .        | 0     | 0     | 0     | 0     | 0     | 4     | 0     | 0     | 0     | 0     | 0     | 0     |
| Peridinium, . .           | 0     | 0     | 0     | 0     | 0     | pr.   | 0     | 1     | 0     | 0     | 0     | 0     |
| Miscellaneous, Zoöglon, . | 738   | 1872  | 328   | 912   | 76    | 58    | 1000  | 600   | 320   | 208   | 88    | 64    |
| TOTAL, . . .              | 738   | 1872  | 328   | 912   | 76    | 62    | 1000  | 601   | 327   | 209   | 88    | 64    |



## BRAINTREE.

## WATER SUPPLY OF BRAINTREE.

*Chemical Examination of Water from the Filler-gallery of the Braintree Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.    |            |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|----------------|------------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.     | Sediment.  | Color. |                         | Free.    | Alb.-minhold. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1893.</b>        |                |            |        |                         |          |               |           |             |           |                  |           |       |
| 9048    | Jan. 4              | V. slight.     | V. slight. | 0.00   | 4.90                    | .0006    | .0090         | .85       | .0650       | .0000     | -                | 2.2       | .0000 |
| 9976    | Feb. 6              | None.          | None.      | 0.02   | 4.90                    | .0004    | .0052         | .92       | .0500       | .0000     | .0912            | 2.3       | .0020 |
| 10102   | Mar. 8              | None.          | None.      | 0.08   | 4.50                    | .0006    | .0056         | .83       | .0400       | .0000     | .1692            | 2.1       | .0025 |
| 10232   | Apr. 11             | None.          | None.      | 0.05   | 4.75                    | .0000    | .0040         | .84       | .0500       | .0000     | .1314            | 1.4       | .0030 |
| 10374   | May 9               | None.          | None.      | 0.03   | 4.45                    | .0000    | .0082         | .79       | .0500       | .0000     | .1752            | 1.3       | .0015 |
| 10495   | June 7              | None.          | None.      | 0.02   | 4.25                    | .0000    | .0052         | .86       | .0300       | .0000     | .1314            | 1.6       | .0025 |
| 10608   | July 6              | None.          | V. slight. | 0.01   | 4.75                    | .0006    | .0030         | .81       | .0280       | .0000     | .0438            | 1.4       | .0000 |
| 10752   | Aug. 9              | Slight, milky. | Slight.    | 0.05   | 4.50                    | .0004    | .0044         | .76       | .0120       | .0003     | .0607            | 1.3       | .0060 |
| 11000   | Sept. 11            | None.          | V. slight. | 0.05   | 4.65                    | .0000    | .0042         | .82       | .0050       | .0002     | .0858            | 1.5       | .0075 |
| 11157   | Oct. 9              | None.          | V. slight. | 0.08   | 5.10                    | .0000    | .0026         | .83       | .0180       | .0001     | .0847            | 1.8       | .0150 |
| 11316   | Nov. 9              | None.          | V. slight. | 0.00   | 4.80                    | .0000    | .0036         | .84       | .0450       | .0000     | .1040            | 1.6       | .0015 |
| 11454   | Dec. 6              | None.          | None.      | 0.00   | 5.10                    | .0000    | .0032         | .84       | .0430       | .0000     | .0546            | 2.5       | .0025 |
| Av.     | .....               | .....          | .....      | 0.03   | 4.72                    | .0002    | .0049         | .83       | .0363       | .0001     | .1029            | 1.8       | .0037 |

*Averages of Analyses of Previous Years.*

|   |          |   |   |      |      |       |       |     |       |       |   |     |   |
|---|----------|---|---|------|------|-------|-------|-----|-------|-------|---|-----|---|
| - | 1887-88* | - | - | 0.07 | 7.14 | .0006 | .0045 | .85 | .0948 | .0003 | - | -   | - |
| - | 1892     | - | - | 0.02 | 4.69 | .0002 | .0030 | .75 | .0192 | .0001 | - | 1.8 | - |

\* June, 1887, to May, 1888.

NOTE to analyses of 1893; Odor, of No. 10102, faintly vegetable; of the others, none. On heating a very faintly vegetable odor was developed in No. 10232. — The samples were collected from a faucet at the pumping station.

*Microscopical Examination*

No. 9848. Diatomaceæ, *Tabellaria*, 62; Nos. 10495 and 10608, Cyanophyceæ, *Anabæna*, 5 in the first, and one in the last; Nos. 10495 to 11157 inclusive each contained a few *Crenothrix* or *Zoëglia*. In the remaining samples no organisms were found.

## BRAINTREE.

*Chemical Examination of Water from Little Pond, Braintree.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 10399   | 1893.<br>May 16     | V. slight.  | Slight.   | 0.30   | 3.75                            | -                    | .0000    | .0190       | -          | -               | .64       | .0030          | .0001     | .4453            | 0.9       |
| 10751   | Aug. 9              | Slight.     | Slight.   | 0.15   | 4.10                            | 1.85                 | .0000    | .0178       | .0140      | .0038           | .74       | .0000          | .0000     | .3256            | 1.3       |
| 10999   | Sept. 11            | Distinct.   | Slight.   | 0.20   | 4.60                            | -                    | .0000    | .0228       | .0212      | .0016           | .76       | .0000          | .0000     | .3666            | 0.9       |
| Av.,    | .....               | .....       | .....     | 0.22   | 4.15                            | -                    | .0000    | .0199       | -          | -               | .71       | .0010          | .0000     | .3792            | 1.0       |

Iron, .0045. Odor, faintly vegetable, becoming stronger in the last two samples on heating. — The samples were collected from the pond near the filter-gallery of the Braintree water works, which is situated on the shore of the pond. It is said that up to the end of 1893, no water had been drawn directly from the pond for the supply of the town.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: In May, 93, chiefly *Diatomacea*; in August, 1893, chiefly *Alga*; in September, 93, chiefly *Alga* and *Cyanophyceae*.

## WATER SUPPLY OF BRIDGEWATER AND EAST BRIDGEWATER. — THE BRIDGEWATERS WATER CO.

In 1892, the works of this company for collecting ground water were again enlarged by sinking five additional six-inch tubular wells in the low ground between the present works and the river. The new wells are located in a line parallel to the river, and are said to range from 100 to 160 feet in depth. Water is pumped from these wells by means of an auxiliary pump into one of the large wells near the pumping station.

**BRIDGEWATER AND EAST BRIDGEWATER.***Chemical Examination of Water from the Wells of the Bridgewater Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.     |              |        | Residue on Evaporation. | AMMONIA. |              | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-----------------|--------------|--------|-------------------------|----------|--------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.      | Sediment.    | Color. |                         | Free.    | Albo-minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1893.</b>        |                 |              |        |                         |          |              |           |             |           |                  |           |       |
| 10474   | June 5              | V. slight.      | Cons.        | 0.02   | 7.00                    | .0002    | .0004        | .44       | .0050       | .0000     | .0487            | 2.6       | .0200 |
| 10596   | July 5              | Slight, clayey. | Cons., sand. | 0.02   | 4.35                    | .0000    | .0074        | .46       | .0400       | .0001     | .0803            | 0.6       | .0069 |
| 10755   | Aug. 7              | None.           | V. slight.   | 0.10   | 6.50                    | .0004    | .0014        | .41       | .0400       | .0000     | .0908            | 2.0       | .0100 |
| 10909   | Sept. 5             | V. slight.      | V. slight.   | 0.02   | 6.75                    | .0000    | .0004        | .40       | .0380       | .0000     | .0000            | 2.5       | .0185 |
| Av.     | .....               | .....           | .....        | 0.04   | 6.15                    | .0002    | .0024        | .43       | .0308       | .0000     | .0550            | 1.9       | .0136 |

*Averages of Analyses of Previous Years.*

|   |          |   |   |      |      |       |       |     |       |       |   |   |   |
|---|----------|---|---|------|------|-------|-------|-----|-------|-------|---|---|---|
| - | 1888-89* | - | - | 0.02 | 4.20 | .0011 | .0016 | .47 | .0307 | .0001 | - | - | - |
|---|----------|---|---|------|------|-------|-------|-----|-------|-------|---|---|---|

\* June, 1888 to June, 1889.

NOTE to 1893 analyses; Odor, none. The samples were collected from a faucet at the pumping station.

*Microscopical Examination of Water from the Wells of the Bridgewater Water Company.*

[Number of organisms per cubic centimeter.]

|                                     | 1893. |       |         |            |
|-------------------------------------|-------|-------|---------|------------|
|                                     | June. | July. | August. | September. |
| Day of examination, . . . . .       | 6     | 6     | 10      | 7          |
| Number of sample, . . . . .         | 10474 | 10596 | 10755   | 10909      |
| PLANTS.                             |       |       |         |            |
| Diatomaceæ, Synedra, . . . . .      | pr.   | 18    | 0       | 0          |
| Fungi, Crenothrix, . . . . .        | 78    | 0     | 5       | 3          |
| ANIMALS.                            |       |       |         |            |
| Infusoria, Trachelomonas, . . . . . | pr.   | 0     | 0       | 1          |
| Miscellaneous, Zoöglæa, . . . . .   | 22    | 3     | 18      | 7          |
| TOTAL, . . . . .                    | 100   | 21    | 23      | 11         |

## BRIDGEWATER AND EAST BRIDGEWATER.

*Chemical Examination of Water from the Town River at Bridgewater, opposite the Wells of the Bridgewaters Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.          |                  |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|----------------------|------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.           | Sediment.        | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                      |                  |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 10473   | 1893.<br>June 5     | Slight.              | Slight.          | 2.70   | 5.70                            | 2.85                 | .0024    | .0292       | .0242      | .0050           | .44       | .0090          | .0002     | 1.4437           | 0.8       |
| 10595   | July 5              | Slight.              | Cons.            | 1.70   | 5.05                            | 2.30                 | .0020    | .0348       | .0312      | .0036           | .40       | .0050          | .0000     | 1.1242           | 1.1       |
| 10754   | Aug. 7              | Distinct,<br>yellow. | Cons.,<br>rusty. | 0.80   | 4.40                            | 2.10                 | .0048    | .0236       | .0192      | .0044           | .54       | .0050          | .0001     | 0.6754           | 1.1       |
| 10968   | Sept. 5             | Slight.              | Slight.          | 2.00   | 6.75                            | 3.45                 | .0012    | .0406       | .0354      | .0052           | .54       | .0050          | .0001     | 1.3960           | 1.6       |
| Av.     | .....               | .....                | .....            | 1.80   | 5.48                            | 2.68                 | .0026    | .0321       | .0275      | .0046           | .48       | .0060          | .0001     | 1.1598           | 1.2       |

Iron, .0275. Odor, distinctly vegetable, becoming stronger on heating, and sometimes also mouldy. — The samples were collected from the river opposite the works of the Bridgewaters Water Company.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: In June, 133; in July, 144; in August, 2,651; in September, 83. The numbers consisted almost wholly of *Crenothrix* and *Zoëglæa*.

## WATER SUPPLY OF BROCKTON.

*Chemical Examination of Water from Salisbury Brook at the Point where it enters the Storage Reservoir of the Brockton Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 9857    | 1893.<br>Jan. 9     | None.       | V. slight. | 1.30   | 7.05                    | 2.90              | .0004    | .0256       | .0236      | .0020      | .66       | .0050       | .0004     | 1.3360           | 2.1       |
| 11296   | Nov. 7              | None.       | V. slight. | 1.70   | 6.55                    | 3.25              | .0008    | .0312       | .0290      | .0022      | .74       | .0000       | .0000     | 1.8160           | 1.6       |

Iron, .0110. Odor, distinctly vegetable. — The samples were collected from the brook just above the reservoir.

*Microscopical Examination.*

No. 9857. Diatomaceæ, *Epithemia*, 1; *Meridion*, 1. Total, 2.

No. 11296. Diatomaceæ, *Cyclotella*, 1; Miscellaneous *Zoëglæa*, 1. Total, 2.

**BROCKTON.***Chemical Examination of Water from Salisbury Brook Storage Reservoir,\* Brockton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|------------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.       | Sediment.       | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                  |                 |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1892.   |                     |                  |                 |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 9858    | Jan. 9              | Slight.          | Slight.         | 0.60   | 4.20                    | 1.70              | .0008    | .0234       | .0184      | .0050      | .48       | .0000       | .0000     | .7600            | 1.4       |
| 9977    | Feb. 7              | Slight.          | Slight, green.  | 0.65   | 4.45                    | 2.00              | .0008    | .0284       | .0224      | .0060      | .50       | .0000       | .0000     | .7811            | 1.4       |
| 10087   | Mar. 7              | Slight.          | V. slight.      | 0.90   | 4.00                    | 2.00              | .0006    | .0184       | .0152      | .0032      | .38       | .0000       | .0000     | .8064            | 1.4       |
| 10213   | Apr. 5              | Slight.          | Cons.           | 0.70   | 3.25                    | 1.20              | .0028    | .0150       | .0128      | .0022      | .37       | .0030       | .0001     | .5183            | 0.3       |
| 10366   | May 8               | V. slight.       | Slight.         | 0.60   | 2.95                    | 1.55              | .0000    | .0154       | .0136      | .0018      | .30       | .0030       | .0000     | .5949            | 0.6       |
| 10481   | June 6              | Slight.          | Cons.           | 0.80   | 3.70                    | 1.65              | .0006    | .0222       | .0176      | .0046      | .36       | .0050       | .0001     | .7738            | 0.5       |
| 10641   | July 11             | Distinct, green. | Slight, yellow. | 0.60   | 3.40                    | 1.95              | .0004    | .0262       | .0228      | .0034      | .34       | .0090       | .0000     | .8249            | 0.5       |
| 10745   | Aug. 8              | Distinct.        | Cons.           | 0.65   | 3.50                    | 1.90              | .0000    | .0216       | .0162      | .0054      | .38       | .0000       | .0000     | .5143            | 0.3       |
| 10966   | Sept. 5             | Distinct.        | Slight.         | 0.60   | 3.40                    | 1.70              | .0016    | .0260       | .0222      | .0038      | .36       | .0030       | .0001     | .6480            | 0.6       |
| 11138   | Oct. 4              | Slight.          | Cons., green.   | 0.60   | 3.00                    | 1.75              | .0000    | .0312       | .0268      | .0044      | .40       | .0000       | .0000     | .5775            | 0.5       |
| 11297   | Nov. 7              | Slight.          | Slight.         | 0.70   | 3.25                    | 1.30              | .0002    | .0286       | .0228      | .0058      | .46       | .0000       | .0001     | .6240            | 0.8       |
| 11449   | Dec. 5              | Slight.          | Cons.           | 0.65   | 4.00                    | 1.65              | .0006    | .0276       | .0240      | .0036      | .47       | .0000       | .0002     | .6201            | 0.5       |
| Av.,    | .....               | .....            | .....           | 0.67   | 3.59                    | 1.70              | .0007    | .0237       | .0196      | .0041      | .40       | .0019       | .0001     | .6703            | 0.7       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887† | - | - | 0.99 | 4.94 | 2.25 | .0033 | .0541 | -     | -     | .33 | .0069 | -     | -     | -   |
| - | 1888  | - | - | 0.76 | 3.77 | 1.61 | .0031 | .0369 | -     | -     | .31 | .0066 | .0001 | -     | -   |
| - | 1889  | - | - | 0.78 | 2.79 | 1.01 | .0028 | .0306 | .0218 | .0078 | .30 | .0048 | .0002 | -     | -   |
| - | 1890  | - | - | 0.73 | 4.07 | 1.98 | .0016 | .0274 | .0219 | .0055 | .32 | .0063 | .0001 | -     | 0.9 |
| - | 1891  | - | - | 0.62 | 3.15 | 1.45 | .0010 | .0213 | .0169 | .0044 | .28 | .0061 | .0001 | -     | 0.6 |
| - | 1892  | - | - | 0.55 | 3.41 | 1.37 | .0004 | .0213 | .0168 | .0045 | .36 | .0030 | .0000 | -     | 0.7 |
| - | 1893  | - | - | 0.67 | 3.59 | 1.70 | .0007 | .0237 | .0196 | .0041 | .40 | .0019 | .0001 | .6545 | 0.7 |

\* In addition to the analyses of water from this reservoir given here, the results of examinations of three samples of water collected from various depths under the ice on March 15, 1893, may be found in the annual report of this Board for 1892, page 340. The additional analyses were made as a part of an investigation to learn the quantity of dissolved oxygen in water under the ice.

† June to December.

NOTE to analyses of 1893; Iron, .0157. Odor generally distinctly vegetable, and very frequently disagreeable. On heating, the odor usually becomes somewhat stronger, and in January and February was very disagreeable. — The samples were collected from the reservoir near the gate-house at a depth of one foot beneath the surface. For a record of heights of water in this reservoir on dates when samples of water were collected for analysis see page 129.

The table of averages shows that there has been a marked decrease in the amount of albuminoid ammonia in this water since the examinations were begun in 1887, indicating a corresponding improvement in its quality. An examination of the monthly analyses during this time, shows that during the earlier years there was a large fluctuation in the amount of albuminoid ammonia in the different seasons of the year, the greatest quantities being found in the summer and early autumn, when abundant growths of microscopic organisms were present in the water. The decrease in the amount of albuminoid ammonia, as shown in the table of averages, is due chiefly to the decrease in the growths of these organisms in summer.

## BROCKTON.

*Microscopical Examination of Water from Salisbury Brook Storage Reservoir, Brockton.*

[Number of organisms per cubic centimeter.]

|                         | 1893. |      |       |       |       |       |       |       |       |       |       |       |
|-------------------------|-------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                         | Jan.  | Feb. | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, .   | 11    | 9    | 8     | 7     | 10    | 7     | 13    | 9     | 6     | 5     | 9     | 7     |
| Number of sample, .     | 9858  | 9977 | 10087 | 10213 | 10365 | 10481 | 10641 | 10745 | 10966 | 11138 | 11297 | 11449 |
| PLANTS.                 |       |      |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, .           | 1182  | 2591 | 146   | 308   | 449   | 98    | 116   | 540   | 2670  | 3300  | 311   | 103   |
| Asterionella, .         | 2     | 5    | 0     | pr.   | 23    | 34    | 56    | 21    | 640   | 0     | 4     | 15    |
| Cyclotella, .           | 0     | 164  | 0     | 1     | 0     | 0     | 2     | 36    | 28    | 0     | 2     | 0     |
| Diatoma, .              | 4     | 0    | 0     | 0     | pr.   | 1     | 5     | 176   | 76    | 9     | 1     | 0     |
| Fragilaria, .           | 0     | 0    | 0     | 0     | 0     | 0     | 6     | 0     | 0     | 0     | 0     | 0     |
| Melosira, .             | 0     | 0    | 0     | 42    | 90    | 33    | 15    | 64    | 244   | 35    | 75    | 0     |
| Navicula, .             | 0     | 0    | 0     | 0     | 16    | 0     | 0     | 0     | 1     | 0     | 0     | 0     |
| Synedra, .              | 1172  | 2422 | 146   | 250   | 230   | 3     | 5     | 7     | 1     | 0     | 26    | 0     |
| Tabellaria, .           | 4     | 0    | 0     | 15    | 40    | 27    | 27    | 236   | 1680  | 3256  | 200   | 88    |
| Cyanophyceæ,            |       |      |       |       |       |       |       |       |       |       |       |       |
| Clathrocystis, .        | 0     | 0    | 0     | 0     | 0     | 5     | 0     | 0     | 1     | 0     | 0     | 0     |
| Algeæ, .                | 1     | 3    | pr.   | 0     | 8     | 45    | 5     | 85    | 17    | 16    | 34    | 2     |
| Pediastrum, .           | 0     | 0    | 0     | 0     | 0     | pr.   | 1     | 2     | 3     | 1     | 2     | 0     |
| Raphidium, .            | 0     | 0    | 0     | 0     | 0     | 0     | 2     | 0     | 6     | 0     | 5     | 0     |
| Scenedesmus, .          | 0     | 0    | pr.   | 0     | 6     | 24    | 0     | 3     | 4     | 15    | 26    | 2     |
| Staurostrum, .          | 0     | 3    | 0     | 0     | 1     | 18    | 0     | 80    | 4     | 0     | 1     | 0     |
| Zoisporæ, .             | 1     | 0    | 0     | 0     | 1     | 3     | 2     | 0     | 0     | 0     | pr.   | 0     |
| ANIMALS.                |       |      |       |       |       |       |       |       |       |       |       |       |
| Rhizopoda, Difflugia, . | 0     | 0    | 0     | 0     | 0     | pr.   | 0     | 0     | 0     | 0     | 1     | 0     |
| Infusoria, .            | 3     | 4    | 4     | 2     | 10    | 5     | 49    | 8     | 6     | 3     | 2     | 5     |
| Cryptomonas, .          | 0     | 3    | 0     | pr.   | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, .      | 0     | 0    | 1     | 0     | 5     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Monas, .                | 0     | 0    | 0     | 0     | 0     | 0     | 20    | 0     | 1     | 0     | 0     | 0     |
| Peridinium, .           | 3     | pr.  | 2     | 2     | 5     | 4     | 28    | 6     | 2     | 3     | 2     | 5     |
| Trachelomonas, .        | 0     | 1    | 1     | pr.   | pr.   | 1     | 1     | 2     | 3     | 0     | 0     | 0     |
| Vermes, .               | 3     | 4    | pr.   | pr.   | pr.   | 1     | 1     | 1     | 0     | 1     | 1     | 0     |
| Aurea, .                | 2     | 1    | 0     | pr.   | pr.   | 1     | 1     | 1     | 0     | 1     | 1     | 0     |
| Polyarthra, .           | 1     | 3    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Rotatorian ova, .       | 0     | pr.  | pr.   | 0     | pr.   | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Miscellaneous, .        | 10    | 0    | 0     | 932   | 42    | 22    | 36    | 340   | 36    | 172   | 70    | 8     |
| Acarina, .              | 0     | 0    | 0     | 0     | 0     | 0     | 0     | .10   | .04   | .02   | 0     | 0     |
| Zoogloea, .             | 10    | 0    | 0     | 932   | 42    | 22    | 36    | 340   | 36    | 172   | 70    | 8     |
| TOTAL, .                | 1199  | 2602 | 150   | 1242  | 509   | 176   | 207   | 974   | 2730  | 3492  | 419   | 118   |

*Aeration.*

Provision was made in the year 1891 for aerating the water supplied to the city of Brockton by forcing air into it through a system of perforated pipes laid near the bottom of the iron tank, as described in the Annual Report of this Board for 1892, page 110. The tank is 62 feet in diameter and 59 feet 4 inches in height, and is open at the top. In the following table is given a comparison of analyses of samples of water collected as it comes from the reservoir and after aeration in the tank.

## BOSTON.

COCHITUATE WORKS. — *Microscopical Examination of Water from a Faucet at the Massachusetts Institute of Technology, Boston.*

[Number of organisms per cubic centimeter.]

|                                  | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                  | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . .      | 2     | 5     | 6     | 3     | 2     | 5     | 2     | 3     | 5     | 2     | 6     | 3     |
| Number of sample, . . . .        | 13572 | 13750 | 13916 | 14069 | 14227 | 14409 | 14564 | 14753 | 14957 | 15291 | 15470 | 15656 |
| PLANTS.                          |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . .              | 143   | 24    | 8     | 14    | 113   | 59    | 415   | 104   | 328   | 51    | 479   | 210   |
| Asterionella, . . . .            | 124   | 20    | 6     | 12    | 57    | 2     | 12    | 0     | 0     | 0     | 325   | 200   |
| Cyclotella, . . . .              | 3     | 0     | 0     | 0     | 0     | 1     | 108   | 36    | 56    | 8     | 5     | 2     |
| Fragilaria, . . . .              | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 10    | 0     | 0     | 0     |
| Melosira, . . . .                | 6     | 0     | 0     | 0     | 35    | 27    | 1     | 0     | 0     | 0     | 8     | 60    |
| Synedra, . . . .                 | 0     | 2     | 1     | 1     | 8     | 5     | 2     | 36    | 6     | 1     | 9     | 0     |
| Tabellaria, . . . .              | 16    | 2     | 1     | 1     | 13    | 24    | 292   | 32    | 256   | 42    | 132   | 3     |
| Cyanophyceæ, . . . .             | 5     | 0     | pr.   | 0     | 0     | 0     | 28    | 3     | 6     | 1     | 11    | 41    |
| Microcystis, . . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 28    | 3     | 6     | 1     | 0     | 0     |
| Oscillaria, . . . .              | 5     | 0     | pr.   | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 11    | 41    |
| Algae, . . . .                   | 0     | 0     | 0     | 0     | 0     | 95    | 300   | 230   | 12    | 0     | 1     | 2     |
| Protooccus, . . . .              | 0     | 0     | 0     | 0     | 0     | 95    | 300   | 228   | 8     | 0     | 0     | 0     |
| Raphidium, . . . .               | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 4     | 0     | 1     | 2     |
| Fungi, Crenothrix, . . . .       | 0     | 0     | 4     | pr.   | 2     | 0     | 0     | 2     | 7     | 1     | 0     | 0     |
| ANIMALS.                         |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . . .               | pr.   | 4     | 0     | 0     | 5     | 0     | 1     | 4     | 5     | 1     | 1     | 6     |
| Dinobryon cases, . . . .         | 0     | 4     | 0     | 0     | 5     | 0     | 0     | 4     | 5     | 1     | 0     | 0     |
| Mallomonas, . . . .              | pr.   | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 1     |
| Trachelomonas, . . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 5     |
| Miscellaneous, Zoöglora, . . . . | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 27    | 0     | 0     | 0     |
| TOTAL, . . . .                   | 154   | 28    | 12    | 14    | 120   | 154   | 744   | 343   | 385   | 54    | 492   | 322   |

## BROCKTON.

*Table showing Height of Water in Salisbury Brook Storage Reservoir, Brockton, on Dates when Samples of Water were collected for Analysis.*

NOTE. — High-water mark is 14.25 feet.

| DATE. — 1893. |   |   |   |   | Height of Water. | DATE. — 1893. |   |   |   |   | Height of Water. |
|---------------|---|---|---|---|------------------|---------------|---|---|---|---|------------------|
|               |   |   |   |   | Feet.            |               |   |   |   |   | Feet.            |
| Jan. 9,       | . | . | . | . | 14.17            | July 11,      | . | . | . | . | 18.64            |
| Feb. 7,       | . | . | . | . | 14.27            | Aug. 8,       | . | . | . | . | 12.67            |
| Mar. 7,       | . | . | . | . | 14.42            | Sept. 5,      | . | . | . | . | 12.23            |
| April 5,      | . | . | . | . | 14.50            | Oct. 4,       | . | . | . | . | 11.35            |
| May 8,        | . | . | . | . | 14.46            | Nov. 7,       | . | . | . | . | 11.75            |
| June 6,       | . | . | . | . | 14.26            | Dec. 5,       | . | . | . | . | 11.75            |

*Chemical Examination of Water from an Underdrain beneath the Main Sewer at Brockton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. |     |
|---------|---------------------|-------------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----|
|         |                     | Turbidity.        | Sediment.         | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |     |
|         |                     |                   |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |     |
| 11560   | 1893.<br>Dec. 28    | Decided,<br>floc. | Cons.,<br>yellow. | 0.02   | 13.80                           | -                    | .0160    | .0030       | -          | -               | 1.78      | .5500          | .0020     | .0885            | 4.2 |

Iron, .0420. Odor, faintly vegetable. — The sample was collected from the underdrain at a man-hole near the Salisbury Plain River south of Perkins Avenue.

The sewerage system of the City of Brockton had not been completed at the time this sample was collected and no sewage had been admitted to the sewers. The sample therefore indicates the average character of the ground water of the region through which the sewer passes.

*Microscopical Examination.*

Fungi, *Crenothrix*, 1920. Miscellaneous, *Zoëglæa*, 320. Total, 2240.



**BROOKFIELD.****WATER SUPPLY OF BROOKFIELD.***Chemical Examination of Water from the Brookfield Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.     |               |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-----------------|---------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.      | Sediment.     | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 10640   | 1893.<br>July 11    | Decided, milky. | Cons., rusty. | 0.5    | 6.00                    | .0006    | .0230       | .14       | .0070       | .0000     | .2555            | 1.5       | .1700 |

Odor, none; becoming faintly vegetable on heating. The sample was collected from a hydrant. The source of supply is a storage reservoir located upon a small brook. This is not a representative sample of the water as it enters the pipes from the reservoir.

*Microscopical Examination.*

Diatomaceæ, *Cyclotella*, 2. Cyanophyceæ, *Merismopedia*, 3. Algæ, *Closterium*, 1; *Protococcus*, 4; *Staurastrum*, 1. Fungi, *Crenothrix*, 84. Vermes, *Rotifer*, 1. Miscellaneous, *Zoëglæa*, 412. Total, 508.

**WATER SUPPLY OF BROOKLINE.**

An important addition was made to the Brookline Water Works in 1893 by the completion of a covered distributing reservoir, which resembles in its general design the covered reservoir constructed by the city of Newton in 1890 and described in the twenty-third annual report of this Board for 1891, page 185. The new reservoir is a rectangular chamber ninety-three feet four inches long, ninety-one feet four inches wide and nineteen and one-half feet deep. The walls are of rubble masonry, coated on the inside with a layer of Portland cement mortar, one-half an inch in thickness. The covering consists of four-inch brick arches, supported on lines of brick piers connected by brick lintel arches, the outer edges bearing on the surrounding walls. The piers are twenty-four inches square and twelve and one-half feet apart on centers. The bottom of the reservoir is formed of a layer of clay puddle two inches in thickness, over which is a layer of cement concrete four inches in thickness. The arches are covered with Portland cement concrete to a level four inches above their crown, and over all is a layer of loam eighteen inches in thickness. Tile drains four inches in diameter are laid beneath the loam in grooves in the concrete to carry off the

**BROOKLINE.**

surplus rain-water. At the top of each line of arches is located a ventilator to allow a free circulation of air.

Water enters the reservoir near the bottom through a cast-iron main twenty inches in diameter, and is drawn out through the same pipe. Provision was made for drawing all the water out of the reservoir if necessary by giving the bottom a slight slope toward a gutter, the bottom of which also has a slight slope and conveys the water to a ten-inch pipe passing through the wall. The reservoir is provided with an overflow 16.2 feet above its bottom, and surplus water flows off in this way into the open distributing reservoir near by. The open reservoir is still retained for use in cases of emergency.

Water is now delivered to consumers without exposure to light at any point, and it is said that since the new reservoir was put in operation the consumers have been very well satisfied with the character of the water, and all complaints of bad tastes and odors have ceased.

*Chemical Examination of Water from a Faucet at the Low Service Pumping Station and from the Covered Reservoir of the Brookline Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1893.</b>        |             |           |        |                         |          |             |           |             |           |                  |           |       |
| 11545   | Dec. 26             | None.       | None.     | 0.0    | 9.15                    | .0026    | .0026       | .54       | .0420       | .0000     | .1344            | 4.2       | .0000 |
| 11546   | Dec. 26             | None.       | None.     | 0.0    | 10.10                   | .0000    | .0026       | .56       | .0300       | .0004     | .1176            | 4.2       | .0375 |

Odor, none. — The first sample was collected from a faucet at the low service pumping station and represents the water as drawn from the filter-gallery or tubular wells. The last sample was collected directly from the new covered reservoir.

*Microscopical Examination.*

No. 11545. No organisms.

No. 11546. Fungi, *Oreothrix*, 18.

## CAMBRIDGE.

## WATER SUPPLY OF CAMBRIDGE.

## Chemical Examination of Water from Fresh Pond, Cambridge.

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.             |              |        | EFFECT OF EXPOSURE. |                   | ACIDITY. |        |             | STRENGTH AS        |       | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------------------|--------------|--------|---------------------|-------------------|----------|--------|-------------|--------------------|-------|------------------|-----------|
|         |                     | Turbidity.              | Sediment.    | Color. | Total.              | Loss on ignition. | Free.    | Total. | Alkalinity. |                    |       |                  |           |
|         |                     |                         |              |        |                     |                   |          |        | Insoluble.  | Sub. precipitated. |       |                  |           |
| 1902.   |                     |                         |              |        |                     |                   |          |        |             |                    |       |                  |           |
| 1895    | Jan. 4              | Slight.                 | Cons.        | 4.36   | 7.94                | 1.33              | .0265    | .0274  | .0284       | .0020              | .0200 | .0004            | .3042 4.6 |
| 1897    | Feb. 4              | V. slight.              | V. slight.   | 1.25   | 7.32                | 2.30              | .0206    | .0214  | .0276       | .0026              | .0000 | .0005            | .4197 3.5 |
| 1897    | Mar. 4              | V. slight.              | Slight.      | 4.40   | 7.01                | 1.71              | .0230    | .0238  | .0234       | .0022              | .0050 | .0001            | .4200 3.5 |
| 1898    | Apr. 4              | Slight.                 | Slight.      | 4.30   | 6.43                | 1.94              | .0225    | .0232  | .0236       | .0026              | .0000 | .0003            | .4553 2.7 |
| 1898    | May 1               | Slight.                 | Cons.        | 4.30   | 6.53                | 2.25              | .0022    | .0041  | .0222       | .0079              | .0050 | .0000            | .4453 2.8 |
| 1899    | June 1              | Distinct, green, milky. | Slight.      | 4.53   | 6.41                | 1.43              | .0065    | .0204  | .0202       | .0054              | .0000 | .0003            | .4300 2.6 |
| 1899    | July 1              | Distinct.               | Cons.        | 4.30   | 6.23                | 2.30              | .0074    | .0230  | .0204       | .0022              | .0000 | .0003            | .4562 3.1 |
| 1899    | Aug. 7              | Slight.                 | Slight.      | 4.25   | 7.30                | 2.30              | .0000    | .0156  | .0200       | .0054              | .0130 | .0005            | .5735 3.0 |
| 1899    | Sept. 1             | Distinct.               | Slight.      | 4.20   | 6.16                | 2.30              | .0020    | .0206  | .0274       | .0054              | .0000 | .0005            | .4120 2.6 |
| 1899    | Oct. 1              | V. slight.              | Cons.        | 4.10   | 6.23                | 2.13              | .0074    | .0278  | .0236       | .0006              | .0130 | .0006            | .3465 3.0 |
| 1899    | Nov. 1              | V. slight.              | Slight.      | 4.50   | 6.73                | 1.43              | .0206    | .0256  | .0236       | .0022              | .0230 | .0013            | .4402 3.2 |
| 1899    | Dec. 5              | Slight.                 | Cons. green. | 4.36   | 7.36                | 1.53              | .0274    | .0236  | .0242       | .0046              | .0200 | .0017            | .3237 3.2 |
| Avg.    | .....               | .....                   | .....        | 4.27   | 6.46                | 1.92              | .0216    | .0202  | .0243       | .0027              | .0235 | .0006            | .4043 3.2 |

## Averages of Analyses of Previous Years.

|   |      |   |   |      |       |      |       |       |       |       |      |       |       |           |
|---|------|---|---|------|-------|------|-------|-------|-------|-------|------|-------|-------|-----------|
| - | 1879 | - | - | 4.04 | 17.32 | 1.94 | .0245 | .0180 | -     | -     | 2.11 | .0208 | -     | -         |
| - | 1880 | - | - | 4.17 | 11.11 | 1.79 | .0232 | .0206 | -     | -     | 1.70 | .0201 | .0007 | -         |
| - | 1886 | - | - | 6.11 | 9.56  | 1.87 | .0245 | .0220 | .0270 | .0050 | 0.00 | .0234 | .0006 | -         |
| - | 1894 | - | - | 6.11 | 9.57  | 1.41 | .0008 | .0227 | .0206 | .0053 | 0.53 | .0203 | .0004 | 4.1       |
| - | 1897 | - | - | 6.13 | 7.94  | 1.80 | .0005 | .0238 | .0202 | .0073 | 0.73 | .0233 | .0004 | 3.8       |
| - | 1899 | - | - | 6.16 | 7.23  | 1.57 | .0006 | .0210 | .0247 | .0049 | 0.47 | .0209 | .0003 | 3.4       |
| - | 1900 | - | - | 5.27 | 6.46  | 1.92 | .0216 | .0202 | .0243 | .0027 | 0.34 | .0235 | .0006 | 4.043 3.2 |

\* June to December.

NOTE in analyses of 1890: Iron, .0110. Odor, generally vegetable, often none. On heating, the odor was generally somewhat stronger, and none of the samples were odorous. — The samples were collected from the pump well at the pumping station. For a record of heights of water in this pond at times when samples of water were collected for analysis see page 126.

It will be noticed from an examination of the averages of analyses of previous years, that there has been a decrease from year to year in the amounts of solids and chlorine in the water of this pond since the examinations were begun, accompanied by a general though not regular increase in color. These changes are due to the introduction of water from Stony Brook into Fresh Pond, which began early in November, 1897, at a time when the water in Fresh Pond was very low. The quantity of water turned into the pond from the brook increases from year to year with the rapidly increasing consumption of water in Cambridge, and the character of the water in the pond is consequently approaching that of the water in the brook.

## CAMBRIDGE.

*Microscopical Examination of Water from Fresh Pond, Cambridge.*

[Number of organisms per cubic centimeter.]

|                                | 1893.        |            |            |            |              |            |            |              |            |              |            |              |
|--------------------------------|--------------|------------|------------|------------|--------------|------------|------------|--------------|------------|--------------|------------|--------------|
|                                | Jan.         | Feb.       | Mar.       | Apr.       | May.         | June.      | July.      | Aug.         | Sept.      | Oct.         | Nov.       | Dec.         |
| Day of examination, .          | 5            | 7          | 7          | 5          | 3            | 7          | 5          | 8            | 6          | 3            | 9          | 7            |
| Number of sample, .            | 9846         | 9967       | 10079      | 10208      | 10349        | 10480      | 10585      | 10739        | 10963      | 11132        | 11294      | 11456        |
| <b>PLANTS.</b>                 |              |            |            |            |              |            |            |              |            |              |            |              |
| Diatomaceæ, . . . . .          | 2,116        | 363        | 411        | 794        | 1,338        | 664        | 612        | 931          | 126        | 1,070        | 693        | 3,064        |
| Asteriolampra, . . . . .       | 0            | 0          | 322        | 686        | 0            | 0          | 0          | 0            | 0          | 0            | 0          | 0            |
| Asterionella, . . . . .        | 396          | 44         | 12         | 18         | 103          | 19         | 56         | 22           | 12         | 1012         | 5          | 152          |
| Cyclotella, . . . . .          | 296          | 264        | 62         | 62         | 0            | 44         | 88         | 104          | 110        | 3            | 44         | 104          |
| Diatoma, . . . . .             | 3            | 9          | pr.        | 0          | 0            | 0          | 0          | 2            | 0          | 0            | 0          | 0            |
| Fragilaria, . . . . .          | 106          | 0          | 1          | 0          | 61           | 7          | 8          | 10           | 0          | 0            | 4          | 46           |
| Melosira, . . . . .            | 536          | 10         | 0          | 16         | 640          | 12         | 0          | 31           | 0          | 0            | 370        | 2160         |
| Stephanodiscus, . . . . .      | 432          | 1          | 2          | 5          | 390          | pr.        | 0          | 1            | 0          | 0            | pr.        | 88           |
| Synedra, . . . . .             | 3            | 0          | 1          | 3          | 26           | 2          | 0          | 45           | 1          | 0            | 0          | 0            |
| Tabellaria, . . . . .          | 344          | 35         | 11         | 4          | 118          | 580        | 460        | 716          | 3          | 55           | 270        | 520          |
| Cyanophyceæ, . . . . .         | 1            | 0          | 0          | 0          | 0            | pr.        | 20         | 172          | 10         | 0            | 0          | 0            |
| Anabaena, . . . . .            | 0            | 0          | 0          | 0          | 0            | 0          | 15         | 12           | 10         | 0            | 0          | 0            |
| Clathrocystis, . . . . .       | 1            | 0          | 0          | 0          | 0            | pr.        | 5          | 8            | pr.        | 0            | 0          | 0            |
| Microcystis, . . . . .         | 0            | 0          | 0          | 0          | 0            | 0          | 0          | 152          | 0          | 0            | 0          | 0            |
| Algæ, . . . . .                | 69           | 6          | 1          | 31         | 2            | 10         | 170        | 204          | 1          | 1            | 25         | 7            |
| Chlorococcus, . . . . .        | 1            | 0          | 0          | 1          | 0            | 0          | 0          | 0            | 0          | 0            | 0          | 4            |
| Closterium, . . . . .          | 64           | 3          | 1          | 2          | 0            | 0          | 0          | 3            | 0          | 0            | 1          | 1            |
| Eudorina, . . . . .            | 0            | 0          | 0          | 0          | 0            | 0          | 0          | 0            | 0          | 0            | 16         | 0            |
| Protococcus, . . . . .         | 0            | 0          | 0          | 0          | 0            | 6          | 168        | 184          | 0          | 0            | 5          | 0            |
| Scenedesmus, . . . . .         | 4            | 3          | pr.        | 0          | 2            | 1          | 1          | 4            | 0          | 0            | pr.        | 0            |
| Staurostrum, . . . . .         | 0            | 0          | 0          | 0          | 0            | 1          | 1          | 4            | 1          | 1            | 3          | 2            |
| Tetraspora, . . . . .          | 0            | 0          | 0          | 0          | 0            | 0          | 0          | 8            | 0          | 0            | 0          | 0            |
| Zoisporæ, . . . . .            | 0            | 0          | 0          | 28         | 0            | 2          | 0          | 1            | 0          | 0            | 0          | 0            |
| Fungi, Crenothrix, . . . . .   | 1            | 4          | pr.        | 1          | 0            | 0          | 0          | 0            | 0          | 30           | 80         | 0            |
| <b>ANIMALS.</b>                |              |            |            |            |              |            |            |              |            |              |            |              |
| Rhizopoda, . . . . .           | 3            | 0          | 0          | 0          | 0            | 0          | 1          | 0            | 1          | 2            | 0          | 28           |
| Actinophrys, . . . . .         | 3            | 0          | 0          | 0          | 0            | 0          | 1          | 0            | pr.        | 2            | pr.        | 28           |
| Diffugia, . . . . .            | 0            | 0          | 0          | 0          | pr.          | 0          | 0          | 0            | 1          | 0            | 0          | 0            |
| Infusoria, . . . . .           | 39           | 1          | 0          | 2          | pr.          | 3          | 5          | 2            | pr.        | 4            | 42         | 4            |
| Ciliated Infusorian, . . . . . | 0            | 0          | 0          | 0          | 0            | 1          | 0          | 0            | 0          | 0            | 0          | 0            |
| Dinobryon cases, . . . . .     | 0            | 0          | 0          | 0          | 0            | 0          | 0          | 0            | 0          | 0            | 20         | 0            |
| Monas, . . . . .               | 0            | 0          | 0          | 0          | pr.          | 1          | 1          | 0            | 0          | 0            | 0          | 0            |
| Peridinium, . . . . .          | 0            | 0          | 0          | pr.        | 0            | 0          | 0          | 2            | pr.        | 3            | pr.        | 0            |
| Suctorina, . . . . .           | 38           | 0          | 0          | 0          | 0            | 0          | 0          | 0            | 0          | 0            | 0          | 0            |
| Trachelomonas, . . . . .       | 1            | 1          | 0          | 2          | 0            | 1          | 4          | 0            | 0          | 1            | 22         | 4            |
| Vermes, . . . . .              | 0            | 0          | 0          | 1          | 0            | 0          | 0          | 1            | 0          | 0            | pr.        | 0            |
| Anurea, . . . . .              | 0            | 0          | 0          | 1          | 0            | 0          | 0          | 0            | 0          | 0            | pr.        | 0            |
| Polyarthra, . . . . .          | 0            | 0          | 0          | 0          | 0            | 0          | 0          | 1            | 0          | 0            | pr.        | 0            |
| <b>Miscellaneous,</b>          |              |            |            |            |              |            |            |              |            |              |            |              |
| Acarina, . . . . .             | 0            | 0          | 0          | 0          | .05          | .04        | .02        | 0            | 0          | 0            | 0          | 0            |
| Zöögica, . . . . .             | 44           | 13         | 80         | 30         | 0            | 2          | 92         | 52           | 10         | 84           | 24         | 2            |
| <b>TOTAL, . . . . .</b>        | <b>2,273</b> | <b>387</b> | <b>492</b> | <b>869</b> | <b>1,340</b> | <b>679</b> | <b>900</b> | <b>1,362</b> | <b>148</b> | <b>1,191</b> | <b>864</b> | <b>3,105</b> |

## CAMBRIDGE.

*Chemical Examination of Water from Stony Brook Storage Reservoir, Waltham.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                     |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 9855    | 1893.<br>Jan. 9     | V. slight.          | Slight.           | 0.55   | 6.50                            | 2.50                 | .0040    | .0228       | .0196      | .0032           | .49       | .0350          | .0001     | .5680            | 2.5       |
| 9978    | Feb. 7              | V. slight.          | Slight.           | 0.55   | 6.10                            | 1.95                 | .0080    | .0186       | .0160      | .0026           | .48       | .0600          | .0002     | .5037            | 2.6       |
| 10077   | Mar. 6              | V. slight.          | V. slight.        | 0.80   | 6.00                            | 2.25                 | .0036    | .0284       | .0258      | .0026           | .39       | .0500          | .0000     | .7056            | 2.2       |
| 10209   | Apr. 4              | Slight.             | Slight.           | 0.65   | 4.40                            | 1.70                 | .0008    | .0214       | .0186      | .0028           | .32       | .0350          | .0000     | .5949            | 1.1       |
| 10356   | May 4               | V. slight.          | Slight.           | 1.00   | 4.70                            | 1.90                 | .0012    | .0240       | .0216      | .0024           | .35       | .0190          | .0003     | .7592            | 1.5       |
| 10472   | June 5              | Slight.             | Slight.           | 1.20   | 4.90                            | 1.95                 | .0014    | .0236       | .0204      | .0032           | .37       | .0070          | .0001     | .8250            | 1.7       |
| 10599   | July 5              | Distinct.           | Slight.           | 0.75   | 5.50                            | 2.45                 | .0002    | .0244       | .0224      | .0020           | .41       | .0250          | .0002     | .6424            | 1.9       |
| 10740   | Aug. 7              | Distinct,<br>green. | Slight,<br>green. | 0.45   | 4.30                            | 1.60                 | .0016    | .0186       | .0152      | .0034           | .40       | .0000          | .0000     | .5589            | 2.3       |
| 10965   | Sept. 5             | Decided.            | Slight,<br>brown. | 0.65   | 4.90                            | 1.80                 | .0004    | .0280       | .0204      | .0076           | .42       | .0050          | .0000     | .5360            | 2.1       |
| 11133   | Oct. 3              | Distinct.           | Cons.             | 0.12   | 4.80                            | 1.95                 | .0002    | .0184       | .0140      | .0044           | .57       | .0000          | .0000     | .4196            | 2.3       |
| 11290   | Nov. 6              | Distinct.           | Cons.,<br>green.  | 0.65   | 5.65                            | 1.55                 | .0016    | .0264       | .0202      | .0062           | .55       | .0090          | .0003     | .6640            | 2.2       |
| 11443   | Dec. 5              | Distinct.           | Slight.           | 0.55   | 6.10                            | 2.00                 | .0004    | .0270       | .0206      | .0064           | .54       | .0130          | .0003     | .5694            | 2.2       |
| Av.     | .....               | .....               | .....             | 0.66   | 5.32                            | 1.97                 | .0020    | .0235       | .0196      | .0039           | .44       | .0208          | .0001     | .5956            | 2.1       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |   |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|---|-----|
| - | 1887* | - | - | 0.81 | 6.21 | 1.82 | .0049 | .0347 | -     | -     | .43 | .0035 | -     | - | -   |
| - | 1888  | - | - | 0.78 | 5.15 | 1.93 | .0031 | .0285 | -     | -     | .34 | .0169 | .0002 | - | -   |
| - | 1889  | - | - | 0.87 | 4.50 | 1.47 | .0032 | .0280 | .0249 | .0031 | .38 | .0162 | .0003 | - | -   |
| - | 1890  | - | - | 0.61 | 5.86 | 2.02 | .0016 | .0222 | .0182 | .0040 | .37 | .0208 | .0002 | - | 2.3 |
| - | 1891  | - | - | 0.56 | 4.99 | 1.86 | .0016 | .0213 | .0183 | .0030 | .34 | .0163 | .0001 | - | 1.9 |
| - | 1892  | - | - | 0.72 | 5.43 | 1.79 | .0015 | .0241 | .0202 | .0039 | .37 | .0208 | .0001 | - | 2.2 |

\* June to November.

NOTE to analyses of 1893; Iron, .0149. Odor, generally distinctly vegetable, rarely unpleasant. On heating the odor often becomes stronger, and sometimes disagreeable. — The samples were collected from the reservoir near the surface at the dam. For heights of water in this reservoir at times when samples of water were collected for analysis see page 136.

## CAMBRIDGE.

*Microscopical Examination of Water from Stony Brook Storage Reservoir,  
Waltham.*

[Number of organisms per cubic centimeter.]

|                       | 1892. |      |       |       |       |       |       |       |       |       |       |       |
|-----------------------|-------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                       | Jan.  | Feb. | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . | 11    | 9    | 7     | 5     | 5     | 6     | 7     | 8     | 6     | 4     | 8     | 7     |
| Number of sample, .   | 9855  | 9978 | 10077 | 10209 | 10356 | 10472 | 10599 | 10740 | 10965 | 11183 | 11290 | 11443 |
| <b>PLANTS.</b>        |       |      |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . .       | 93    | 14   | 0     | 27    | 102   | 99    | 2,347 | 501   | 2,008 | 268   | 1,352 | 1,171 |
| Asterionella, . .     | 11    | 0    | 0     | 0     | 0     | 4     | 700   | 13    | 0     | 33    | 520   | 360   |
| Cyclotella, . .       | 17    | 0    | 0     | pr.   | pr.   | 6     | 7     | 420   | 1,400 | 52    | 68    | 88    |
| Diatoma, . .          | 1     | 0    | 0     | 0     | 2     | 0     | 0     | 0     | 420   | 0     | 0     | 1     |
| Fragilaria, . .       | 3     | 0    | 0     | 0     | 5     | 0     | 0     | 0     | 14    | 25    | 4     | 0     |
| Melosira, . .         | 12    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Meridion, . .         | 0     | 0    | 0     | 20    | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Navicula, . .         | 1     | 0    | 0     | pr.   | 1     | 1     | 0     | 1     | 2     | 2     | 0     | 1     |
| Synedra, . .          | 6     | 14   | 0     | 3     | 82    | 4     | 740   | 15    | 76    | 28    | 0     | 1     |
| Tabellaria, . .       | 42    | pr.  | 0     | 4     | 11    | 84    | 900   | 52    | 96    | 128   | 760   | 720   |
| Cyanophyceæ, . .      | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 9     | 25    | 61    | 0     | 0     |
| Anabaena, . .         | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 8     | 19    | 1     | 0     | 0     |
| Clathrocystis, . .    | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 1     | 6     | 0     | 0     | 0     |
| Celosphaerium, . .    | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 60    | 0     | 0     |
| Algæ, . . . .         | 0     | 0    | 0     | 0     | pr.   | 0     | 101   | 8     | 48    | 0     | 0     | 4     |
| Closterium, . .       | 0     | 0    | 0     | 0     | pr.   | 0     | 1     | 3     | 40    | 0     | 0     | 0     |
| Protococcus, . .      | 0     | 0    | 0     | 0     | 0     | 0     | 100   | 0     | 5     | 0     | 0     | 4     |
| Staurostrum, . .      | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 5     | 3     | 0     | 0     | 0     |
| <b>ANIMALS.</b>       |       |      |       |       |       |       |       |       |       |       |       |       |
| Rhizopoda, . .        | 3     | 0    | 0     | 0     | pr.   | 0     | 0     | 0     | 1     | 0     | 4     | 0     |
| Actinophrys, . .      | 3     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 0     |
| Diffugia, . .         | 0     | 0    | 0     | 0     | pr.   | 0     | 0     | 0     | 1     | 0     | 0     | 0     |
| Infusoria, . .        | 0     | pr.  | 0     | 0     | 2     | 1,607 | 196   | 40    | 15    | 3     | 0     | 0     |
| Dinobryon, . .        | 0     | 0    | 0     | 0     | 0     | 0     | 4     | 0     | 10    | 0     | 0     | 0     |
| Dinobryon cases, . .  | 0     | 0    | 0     | 0     | 1     | 1,000 | 192   | 0     | 0     | 0     | 0     | 0     |
| Euglena, . .          | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     |
| Peridinium, . .       | 0     | 0    | 0     | 0     | 1     | 0     | 0     | 40    | 2     | 1     | 0     | 0     |
| Trachelomonas, . .    | 0     | pr.  | 0     | 0     | 0     | 7     | 0     | 0     | 1     | 2     | 0     | 0     |
| Miscellaneous, . .    | 100   | 3    | 13    | 0     | 7     | 52    | 2     | 48    | 2     | 100   | 28    | 36    |
| Acarina, . .          | 0     | 0    | 0     | 0     | 0     | 0     | .02   | .01   | .04   | 0     | 0     | 0     |
| Zoöglæa, . .          | 100   | 3    | 13    | 0     | 7     | 52    | 2     | 48    | 2     | 100   | 28    | 36    |
| TOTAL, . . . .        | 196   | 17   | 13    | 27    | 111   | 1,758 | 2,646 | 606   | 2,099 | 432   | 1,384 | 1,211 |

## CAMBRIDGE.

*Table showing Heights of Water in Fresh Pond and in Stony Brook Storage Reservoir on the Dates when Samples of Water were collected for Analysis.*

[Heights are in feet above Cambridge city base.]

| FRESH POND. HIGH WATER, 16.85. |   |                  | STONY BROOK RESERVOIR. ROLLWAY, 81.00. |   |                  |
|--------------------------------|---|------------------|----------------------------------------|---|------------------|
| DATE.                          |   | Height of Water. | DATE.                                  |   | Height of Water. |
| 1892.                          |   |                  | 1892.                                  |   |                  |
| Jan. 4.,                       | . | 14.95            | Jan. 9,                                | . | 79.20            |
| Feb. 6.,                       | . | 15.05            | Feb. 7,                                | . | 75.92            |
| Mar. 6.,                       | . | 16.31            | Mar. 6,                                | . | 81.14            |
| April 4.,                      | . | 16.85            | April 4,                               | . | 81.59            |
| May 3.,                        | . | 16.89            | May 4,                                 | . | 81.75            |
| June 5.,                       | . | 16.63            | June 5,                                | . | 81.14            |
| July 5.,                       | . | 16.90            | July 5,                                | . | 79.75            |
| Aug. 7.,                       | . | 16.72            | Aug. 7,                                | . | 72.60            |
| Sept. 5.,                      | . | 16.54            | Sept. 5,                               | . | 65.10            |
| Oct. 3.,                       | . | 13.90            | Oct. 3,                                | . | 66.82            |
| Nov. 6.,                       | . | 11.84            | Nov. 6,                                | . | 71.84            |
| Dec. 5.,                       | . | 12.65            | Dec. 5,                                | . | 71.75            |

## WATER SUPPLY OF CANTON.

The advice of the State Board of Health to the town of Canton relative to a proposed additional water supply from the valley of Beaver Brook above the present pumping station of the Canton Water Works, may be found on pages 14 and 15 of this volume. In the following table is given the analyses of samples of water collected in connection with the investigation for this additional water supply.

*Chemical Examination of Water from Tubular Test Wells, in the Valley of Beaver Brook, Canton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |                    |        | Residue on Evaporation. | AMMONIA. |             |           | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|--------------------|--------------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.         | Sediment.          | Color. |                         | Free.    | Albuminoid. | Chlorine. | Nitrates.   | Nitrites. |                  |           |       |
| 1892.   |                     |                    |                    |        |                         |          |             |           |             |           |                  |           |       |
| 9922    | Jan. 24             | V. slight, clayey. | V. slight, earthy. | 0.00   | 3.75                    | .0000    | .0006       | .42       | .0150       | .0001     | .0000            | 1.3       | .0110 |
| 9923    | Jan. 24             | Decided, milky.    | Cons., rusty.      | 0.03*  | 6.60                    | .0234    | .0012       | .21       | .0120       | .0000     | .0109            | 2.3       | .4100 |
| 9957    | Feb. 1              | None.              | V. slight.         | 0.02   | 5.65                    | .0000    | .0006       | .32       | .0000       | .0000     | .0197            | 2.7       | .0060 |

\* This sample when received at the laboratory had a color of 0.70 caused by minute particles of iron rust in suspension, but subsequently, after the iron rust had precipitated, became nearly colorless.

Odor, of No. 9923, faint; of the others, none. — Sample No. 9922 was collected from tubular test well No. 2, 20 feet deep, driven through 11 feet of muck and five feet of sand into gravel. No. 9923, from test well No. 3, 20 5 feet deep, driven through 1.45 feet of muck and 2 feet of fine sand into gravel. No. 9957, from test well No. 5, 20 feet deep, driven through 5 feet of muck and 5 feet of fine sand into gravel. Water was pumped from the wells with a hand pump before collecting the samples, for periods varying from 2 to 4½ hours. The wells were located in the vicinity of Beaver Brook, at a point where it is joined by a small branch from the south, about half a mile above the pumping station of the Canton Water Works.

## Microscopical Examination.

No organisms.

## CHELSEA.

## WATER SUPPLY OF CHELSEA.

(See *Boston, Mystic Works.*)

## WATER SUPPLY OF CHESTER.

*Description of Works.* — The population of the town in 1890 was 1,295. The population of the main village, which is the only portion of the town supplied with water, is said to be about 800. The works are owned by C. L. Goodhue. Water was introduced in November, 1893, and was supplied to about 60 families at the end of the year.

The source of supply is Austin Brook, a tributary of Walker Brook. Water is drawn from Austin Brook at a point about 1,200 feet from its mouth, and less than a mile west of the village of Chester, where a small reservoir has been constructed at a sufficient elevation to supply the town by gravity. It is said that the reservoir is formed by a dam about 8 feet in height, and covers an area 60x80 feet to an average depth of about 6 feet.

The brook, above the point where the dam is located, drains an area about  $1\frac{1}{4}$  square miles, which is mainly pasture and woodland; it is said that there is but one dwelling house on this area.

The distributing mains are of cast-iron, and the service pipes are of galvanized iron.

The advice of the State Board of Health to the town of Chester, with reference to taking a supply of water from Austin and other brooks, may be found on pages 15 to 17 of this volume.

*Chemical Examination of Water from Austin, Blandford and Walker Brooks, and Horn Pond in Chester and Becket.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. |           |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  | Hardness. |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1893.   |                     |             |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 10430   | May 22              | None.       | V. slight. | 0.08   | 2.40                            | 0.65                 | .0008    | .0046       | .0038      | .0008           | .05       | .0000          | .0000     | .2062            | 0.8       |
| 10431   | May 22              | None.       | V. slight. | 0.08   | 2.75                            | 0.75                 | .0010    | .0052       | .0044      | .0008           | .06       | .0030          | .0000     | .2062            | 0.8       |
| 10432   | May 22              | V. slight.  | Slight.    | 0.30   | 2.50                            | 1.05                 | .0008    | .0158       | .0130      | .0028           | .05       | .0050          | .0001     | .4162            | 0.8       |
| 10433   | May 22              | V. slight.  | V. slight. | 0.48   | 3.05                            | 1.05                 | .0006    | .0104       | -          | -               | .04       | .0000          | .0000     | .4987            | 0.8       |

Iron, in No. 10430, .0060; in No. 10431, .0025; in the remaining samples, none. Odor of the first two samples, none; of the third, distinctly vegetable, disappearing on heating; of the last, very faintly vegetable. — The first sample was collected from Austin Brook; the second, from Blandford Brook, about a third of a mile from its mouth; the third, from Walker Brook, about a mile from the Chester railroad station, and the last from Horn Pond.

*Microscopical Examination.*

The number of organisms per cubic centimeter in these samples was as follows: No. 10430, 1; No. 10431, 9; No. 10433, not examined; No. 10432, 45.



## CHICOPEE.

## WATER SUPPLY OF CHICOPEE.

Until 1893 the city of Chicopee had been supplied with water from various sources as follows :—

Chicopee Centre, having a population in 1890 of about 7,500, was supplied with water by the Chicopee Water Company from Dingle Brook, and from wells, partly by gravity and partly by pumping.

Chicopee Falls (population in 1890, 5,553) was supplied chiefly from works owned by the district, with water pumped by the Chicopee Manufacturing Company from the Chicopee River within the village.

Willimansett Village (population in 1890, about 300) was supplied by the Willimansett Aqueduct Company with water by gravity from a small brook.

In 1892 the city of Chicopee acquired possession of the works of the Chicopee Water Company and of the Willimansett Aqueduct Company.

In the winter and early spring of 1892 there was a mild epidemic of typhoid fever in Chicopee Falls, and the State Board of Health, after investigation,\* found reason to believe that the epidemic was due to the use of water from the Chicopee River, a stream which receives the sewage of several thousand people, and taking these results in connection with investigations in other places showing that a polluted running stream is a very dangerous source of water supply, advised the city to secure a pure water supply for Chicopee Falls and to discontinue the use of river water. The new supply was completed at the end of 1893, and the use of water from the Chicopee River was discontinued.

*Description of Works.*—The new sources of supply are Morton and Cooley Brooks, the waters of which are taken near their confluence, about  $1\frac{1}{2}$  miles northeast of Chicopee Falls. Cooley Brook is a tributary of the Chicopee River from the north, and a large part of its course is through a ravine in the great sandy plain between Chicopee and Granby. Owing to the character of its watershed, which allows much of the water falling upon it to pass into the ground and move gradually toward the brook, which it finally reaches in the form of springs, its flow is well maintained in a dry

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\* See "An Investigation of an Outbreak of Typhoid Fever in Chicopee Falls apparently due to infected Water Supply," made under the direction of Prof. W. T. Sedgwick in the twenty-fourth annual report of the State Board of Health for 1892, pages 705-714.

## CHICOPEE.

season. A dam about 170 feet long and 10 feet in height has been constructed across the brook at a point about three-fourths of a mile from its mouth, forming a small reservoir said to have a capacity when full of 5,500,000 gallons. All the loam and vegetable matter was removed from the area to be flowed up to the level at which it is proposed to hold the water, which for the present will be only high enough to divert the water into a conduit leading to the pumping station.

Morton Brook is a small branch of Cooley Brook, fed almost wholly by springs, which enters the latter a short distance below the dam just described. A low dam has been constructed across this brook a short distance above its mouth, forming a small reservoir about 80 feet long, 40 feet wide, and averaging three feet in depth, which was thoroughly cleaned.

A cast-iron conduit pipe 16 inches in diameter conveys water by gravity from Cooley Brook to a receiving basin at the pumping station, a distance of 2,434 feet. A branch conduit 8 inches in diameter, also of cast-iron, conveys the water from Morton Brook to the main conduit, a distance of 750 feet. It is proposed to take the supply as far as possible from Morton Brook, because of the better quality of its water.

The receiving basin is 107 feet long, 77 feet wide and 8 feet deep at high water. It is oval in shape, with sloping sides, and has a capacity of 350,000 gallons. The slopes are paved with bricks laid in cement, and the bottom is covered with a layer of Portland cement concrete, 6 inches in thickness, over which is a layer of gravel 4 inches in thickness. At the end of the basin where the conduit enters, there is a sand chamber 9 feet long, 6 feet wide and 8 feet deep, designed to catch heavy suspended matter, and from this chamber the water overflows into the main portion of the basin. The surplus water brought to the basin passes off through an overflow formed by a 20-inch pipe set perpendicularly in the centre of the basin, and discharging into a pipe leading to Cooley Brook.

Water is pumped from the basin to the city and to an open iron tank 55 feet in diameter and 60 feet in height, situated a short distance from the main pipe between the pumping station and the city. All new distributing mains are of cast-iron ; new service pipes are of galvanized iron and lead.

**CHICOPEE.**

The old works of the Chicopee Water Company will still be used as a low-service supply for the lower portion of the city.

The water supply of the village of Willimansett was introduced in the summer of 1892. The source of supply is a small brook, a tributary of the Connecticut River from the east, which flows from the westerly side of the great sandy plain already mentioned. A dam about 10 feet in height has been constructed across the brook, forming a small reservoir at a point where the elevation is sufficient to supply the village by gravity. Distributing mains are of cast-iron. Service pipes are of galvanized iron and lead.

*Chemical Examination of Water from Morton and Cooley Brooks in Chicopee.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                             |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |          | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.                   | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrate.       | Nitrite. |                  |           |
|         |                     |             |                             |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |          |                  |           |
| 1893.   |                     |             |                             |        |                                 |                      |          |             |            |                 |           |                |          |                  |           |
| 11399   | Nov. 27             | V. slight.  | Cons.<br>sandy.             | 0.02   | 3.50                            | 0.40                 | .0000    | .0104       | .0094      | .0010           | .13       | .0180          | .0000    | .1505            | 1.6       |
| 11400   | Nov. 27             | V. slight.  | Cons.<br>earthy &<br>sandy. | 0.02   | 3.45                            | 0.65                 | .0000    | .0044       | .0016      | .0028           | .00       | .0080          | .0000    | .1462            | 1.4       |

Iron, in No. 11399, .0050; in No. 11400, .0050. Odor, very faintly vegetable, disappearing on heating. — The first sample was collected from the receiving basin at the pumping station and represents water from Morton Brook. The second sample was collected from Cooley Brook at the new dam.

*Microscopical Examination.*

No. 11399. Diatomaceæ, *Meridion*, 1; *Synedra*, 1. Fungi, *Cladothrix*, 2. Miscellaneous, *Zoëglæa*, 5. Total, 9.

No. 11400. Diatomaceæ, *Gomphonema*, 1; *Navicula*, 2; *Synedra*, 1; *Tabellaria*, 1. Algæ, *Closterium*, 1. Fungi, *Crenothrix*, 2. Miscellaneous, *Zoëglæa*, 6. Total, 14.

## COHASSET.

## WATER SUPPLY OF COHASSET. — COHASSET WATER COMPANY.

*Chemical Examination of Water from the Tubular Wells of the Cohasset Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment.      | Color. |                         | Free.    | Albaminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | 1893.               |                  |                |        |                         |          |             |           |             |           |                  |           |       |
| 10137   | Mar. 17             | Distinct, milky. | Slight, rusty. | 0.12   | 21.15                   | .0008    | .0002       | 1.93      | .0180       | .0000     | .0079            | 11.6      | .0650 |
| 10551   | June 22             | Slight, milky.   | None.          | *0.00  | 16.50                   | .0000    | .0028       | 1.63      | .0180       | .0000     | .0395            | 7.8       | .0270 |
| 11099   | Sept. 19            | Distinct, milky. | Slight.        | 0.10   | 16.50                   | .0000    | .0006       | 1.61      | .0350       | .0001     | .0369            | 7.6       | .0500 |
| 11096   | Sept. 26            | Distinct, milky. | None.          | 0.20   | 16.20                   | .0000    | .0004       | 1.41      | .0200       | .0001     | .0738            | 8.0       | .0300 |
| 11218   | Oct. 17             | Distinct, milky. | None.          | 0.18   | 16.10                   | .0000    | .0000       | 1.63      | .0400       | .0000     | .0445            | 8.1       | .0385 |
| 11349   | Nov. 18             | Distinct, milky. | None.          | 0.20   | 16.40                   | .0000    | .0000       | 1.61      | .0270       | .0001     | .0462            | 8.6       | .0600 |
| Avg.    | .....               | .....            | .....          | 0.16   | 17.14                   | .0001    | .0007       | 1.64      | .0263       | .0001     | .0415            | 8.6       | .0451 |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |       |       |       |      |       |       |       |     |       |
|---|-------|---|---|------|-------|-------|-------|------|-------|-------|-------|-----|-------|
| - | 1887† | - | - | 0.00 | 15.21 | .0005 | .0010 | 1.69 | .0196 | -     | -     | -   | -     |
| - | 1888  | - | - | 0.01 | 15.20 | .0001 | .0021 | 1.50 | .0311 | .0003 | -     | -   | -     |
| - | 1890‡ | - | - | 0.00 | 11.64 | .0001 | .0022 | 1.48 | .0230 | .0002 | -     | -   | -     |
| - | 1890§ | - | - | 0.00 | -     | .0000 | .0048 | 1.48 | .0150 | .0003 | -     | -   | -     |
| - | 1893  | - | - | 0.16 | 17.14 | .0001 | .0007 | 1.64 | .0263 | .0001 | .0415 | 8.6 | .0451 |

\* This sample was turbid when received and the color was determined after filtration.

† June to December.

‡ January to May.

§ February.

NOTE to analyses of 1893: Odor, none. — The samples were collected from a faucet in the pumping station while pumping.

This water is beginning to show some of the characteristics of an "iron" water, namely, a noticeable turbidity, sediment and color, and the presence of iron and of certain microscopic organisms often found in such waters. The determinations of turbidity, sediment and color in a sample of water of this class vary with the length of time that the water has been exposed to the air after it has been drawn from the ground, since they are dependent upon the amount of iron which has been thereby oxidized and converted into an insoluble form. When the iron is all precipitated out, the water

**COHASSET.**

resumes its original appearance, free from color and turbidity. These results of turbidity, sediment and color are, therefore, only of value as showing a condition which the water may assume, and should not be used for making comparisons between the different samples.

*Microscopical Examination of Water from the Tubular Wells of the Cohasset Water Company.*

[Number of organisms per cubic centimeter.]

|                               | 1893.  |       |       |       |       |       |
|-------------------------------|--------|-------|-------|-------|-------|-------|
|                               | March. | June. | Sept. | Sept. | Oct.  | Nov.  |
| Day of examination, . . . .   | 18     | 23    | 22    | 28    | 20    | 21    |
| Number of sample, . . . .     | 10137  | 10551 | 11069 | 11096 | 11218 | 11349 |
| <b>PLANTS.</b>                |        |       |       |       |       |       |
| Fungi, Crenothrix, . . . .    | 0      | 8     | 1,200 | 44    | 40    | 120   |
| Miscellaneous, Zoöglaa, . . . | 0      | 3     | 24    | 24    | 7     | 42    |
| <b>TOTAL,</b> . . . . .       | 0      | 11    | 1,224 | 68    | 47    | 162   |

**WATER SUPPLY OF CONCORD.**

*Chemical Examination of Water from Sandy Pond, Lincoln.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. |           |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  | Hardness. |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1893.   |                     |             |            |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 10141   | Mar. 20             | Slight.     | Slight.    | 0.05   | 1.70                    | 0.60              | .0068    | .0148       | .0120      | .0028      | .21       | .0000       | .0000     | .1620            | 0.6       |
| 10269   | Apr. 19             | V. slight.  | V. slight. | 0.08   | 2.20                    | 0.60              | .0002    | .0086       | .0060      | .0020      | .24       | .0000       | .0001     | .1642            | 0.5       |

Iron, .0098. Odor, none; on standing two days, a faintly unpleasant odor developed in the first sample. On heating, a faint odor was developed in each sample. — The first sample was collected from the pond; the last, from a faucet in the town.

*Microscopical Examination.*

No. 10141. Diatomaceæ, *Asterionella*, 1; Vermes, *Anurea*, Fr.; Total, 1.

No. 10269. Diatomaceæ, *Asterionella*, Fr.; Infusoria, *Dinobryon*, 1; *Dinobryon cases*, 10. Total, 11.

## DANVERS.

## WATER SUPPLY OF DANVERS.

In the act of the legislature giving the town of Danvers the right to supply itself with water, the town was granted permission to take its supply from Middleton Pond, in Middleton, and Swan's Pond, in North Reading. The latter is situated a little less than half a mile from Middleton Pond and its surface is about twenty-two feet higher. Water was introduced from Middleton Pond in 1876, but the works were not extended to Swan's Pond until 1893, when a connection between the two ponds was made by laying a six-inch cast-iron pipe. Swan's Pond is said to have an area of about forty-five acres.

## WATER SUPPLY OF DEDHAM. — DEDHAM WATER COMPANY.

*Chemical Examination of Water from the Well of the Dedham Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albu- minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1893.</b>        |             |           |        |                         |          |               |           |             |           |                  |           |       |
| 9920    | Jan. 24             | None.       | None.     | 0.0    | 10.15                   | .0000    | .0016         | .98       | .2400       | .0001     | -                | 4.4       | .0000 |
| 10461   | May 31              | None.       | None.     | 0.0    | 10.80                   | .0000    | .0012         | .92       | .2500       | .0000     | .0637            | 4.0       | .0000 |
| 10674   | July 13             | None.       | None.     | 0.0    | 10.10                   | .0000    | .0013         | .88       | .2500       | .0000     | .0780            | 3.9       | .0000 |
| 11356   | Nov. 21             | None.       | None.     | 0.0    | 9.50                    | .0000    | .0050         | .90       | .1900       | .0000     | .0924            | 4.3       | .0000 |
| Average | .....               | .....       | .....     | 0.0    | 10.14                   | .0000    | .0024         | .92       | .2325       | .0000     | .0780            | 4.2       | .0000 |

*Averages of Analyses of Previous Years.*

|   |       |   |   |     |       |       |       |     |       |       |       |     |       |
|---|-------|---|---|-----|-------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1887* | - | - | 0.0 | 10.97 | .0002 | .0012 | .97 | .2690 | -     | -     | -   | -     |
| - | 1888† | - | - | 0.0 | 10.38 | .0002 | .0011 | .93 | .2310 | .0000 | -     | -   | -     |
| - | 1889‡ | - | - | 0.0 | 9.15  | .0000 | .0020 | .93 | .1700 | .0000 | -     | -   | -     |
| - | 1892  | - | - | 0.0 | 10.65 | .0000 | .0006 | .95 | .2982 | .0000 | -     | 4.4 | .0007 |
| - | 1893  | - | - | 0.0 | 10.14 | .0000 | .0024 | .92 | .2325 | .0000 | .0780 | 4.2 | .0000 |

\* June to December.

† January to May.

‡ April.

NOTE to analyses of 1893: Odor, none. — The samples were collected from a faucet at the pumping station.

*Microscopical Examination, 1893.*

A very few organisms, chiefly Diatomaceæ, were found in Nos. 10461 and 10674. No organisms were found in the remaining samples.

## CAMBRIDGE.

## Chemical Examination of Water from Stony Brook Storage Reservoir, Waltham.

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |                    |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>as |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|--------------------|--------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.         | Sediment.          | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                    |                    |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 13608   | 1895.<br>Jan. 7     | V. slight.         | Slight.            | 0.68   | 7.00                            | 2.60                 | .0022    | .0380       | .0186      | .0194           | .62       | .0520          | .0001     | .6708            | 3.0       |
| 13767   | Feb. 5              | V. slight.         | V. slight.         | 0.75   | 6.95                            | 3.35                 | .0010    | .0250       | .0232      | .0018           | .56       | .0400          | .0000     | .8058            | 2.5       |
| 13921   | Mar. 5              | V. slight.         | V. slight.         | 0.63   | 6.60                            | 2.10                 | .0016    | .0180       | .0174      | .0006           | .55       | .0430          | .0001     | .8376            | 2.3       |
| 14084   | Apr. 2              | V. slight.         | Slight.            | 0.83   | 5.50                            | 2.30                 | .0016    | .0238       | .0220      | .0018           | .39       | .0300          | .0001     | .7469            | 1.7       |
| 14245   | May 6               | Slight.            | Slight.            | 1.05   | 4.90                            | 2.25                 | .0000    | .0232       | .0208      | .0024           | .52       | .0180          | .0000     | .8431            | 1.9       |
| 14414   | June 5              | Distinct.          | Slight.            | 1.00   | 5.55                            | 2.80                 | .0036    | .0292       | .0290      | .0032           | .45       | .0180          | .0002     | .8702            | 2.2       |
| 14592   | July 9              | Distinct.          | Cons.              | 0.90   | 4.80                            | 1.55                 | .0018    | .0308       | .0240      | .0068           | .45       | .0120          | .0002     | .7426            | 2.1       |
| 14789   | Aug. 7              | Slight,<br>green.  | Slight.            | 0.60   | 5.20                            | 2.40                 | .0018    | .0256       | .0216      | .0040           | .45       | .0150          | .0002     | .6630            | 2.6       |
| 15302   | Oct. 2              | Distinct.          | Slight.            | 0.55   | 5.80                            | 2.30                 | .0010    | .0324       | .0310      | .0014           | .47       | .0030          | .0001     | .6100            | 2.1       |
| 15481   | Nov. 5              | Distinct.          | Slight.            | 1.15   | 6.85                            | 3.15                 | .0020    | .0350       | .0298      | .0052           | .49       | .0230          | .0001     | 1.1505           | 2.2       |
| 15664   | Dec. 3              | Slight,<br>clayey. | Slight,<br>earthy. | 1.15   | 5.70                            | 2.75                 | .0000    | .0272       | .0238      | .0034           | .40       | .0180          | .0000     | .9610            | 1.8       |
| Av.     | .....               | .....              | .....              | 0.84   | 5.90                            | 2.41                 | .0015    | .0280       | .0235      | .0045           | .49       | .0253          | .0001     | .7910            | 2.2       |

## Averages by Years.

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 0.81 | 6.21 | 1.82 | .0049 | .0347 | -     | -     | .43 | .0035 | -     | -     | -   |
| - | 1888  | - | - | 0.78 | 5.15 | 1.93 | .0031 | .0285 | -     | -     | .34 | .0169 | .0002 | -     | -   |
| - | 1889  | - | - | 0.87 | 4.59 | 1.47 | .0032 | .0280 | .0249 | .0031 | .38 | .0162 | .0003 | -     | -   |
| - | 1890  | - | - | 0.61 | 5.86 | 2.02 | .0016 | .0222 | .0182 | .0040 | .37 | .0208 | .0002 | -     | 2.3 |
| - | 1891  | - | - | 0.56 | 4.99 | 1.86 | .0016 | .0213 | .0183 | .0030 | .34 | .0163 | .0001 | -     | 1.9 |
| - | 1892  | - | - | 0.72 | 5.43 | 1.79 | .0015 | .0241 | .0202 | .0039 | .37 | .0208 | .0001 | -     | 2.2 |
| - | 1893  | - | - | 0.66 | 5.32 | 1.97 | .0020 | .0235 | .0196 | .0039 | .44 | .0208 | .0001 | .5956 | 2.1 |
| - | 1894  | - | - | 0.73 | 5.61 | 2.03 | .0018 | .0211 | .0189 | .0022 | .46 | .0174 | .0001 | .6422 | 2.1 |
| - | 1895  | - | - | 0.84 | 5.90 | 2.41 | .0015 | .0280 | .0235 | .0045 | .49 | .0253 | .0001 | .7910 | 2.2 |

\* June to November.

NOTE to analyses of 1895: Odor, generally faintly vegetable, very rarely none; on heating the odor generally became stronger and sometimes mouldy. — The samples were collected from the reservoir, near the surface, at the dam. For monthly record of height of water in this reservoir, see page 135.

## DEERFIELD.

## DEERFIELD.

*Chemical Examination of Water from Mill River and Clapp's Trout Brook in Deerfield and Roaring Brook in Whately.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. |           |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. | Oxygen Consumed. | Hardness. |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 11401   | 1893.<br>Nov. 27    | None.       | V. slight. | 0.00   | 7.35                            | 0.50                 | .0000    | .0026       | .0020      | .0006           | .11       | .0400          | .0000     | .1290            | 5.6       |
| 11402   | Nov. 27             | None.       | V. slight. | 0.00   | 6.40                            | 0.55                 | .0006    | .0040       | .0032      | .0008           | .10       | .0120          | .0000     | .1204            | 4.3       |
| 11403   | Nov. 27             | None.       | V. slight. | 0.04   | 6.00                            | 0.55                 | .0002    | .0052       | .0042      | .0010           | .12       | .0080          | .0000     | .1462            | 3.9       |

Iron, insignificant. Odor of all samples, very faintly vegetable. — The first sample was collected from Mill River in Deerfield near the boundary line between Conway and Deerfield; the second, from Clapp's Trout Brook, a tributary of Mill River in Deerfield, and the last from Roaring Brook in Whately Glen, in the northern part of Whately.

*Microscopical Examination.*

No. 11401. Diatomaceæ, *Navicula*, 1; *Pinnularia*, 1; *Synedra*, 10. Miscellaneous, *Zoëglæa*, 3. Total, 15.

No. 11402. Diatomaceæ, *Synedra*, 5.

No. 11403. Diatomaceæ, *Synedra*, 3. Miscellaneous, *Zoëglæa*, 1. Total, 4.

## WATER SUPPLY OF EAST BRIDGEWATER.

(See *Bridgewater*.)

## WATER SUPPLY OF EASTHAMPTON.

Works for taking a water supply from a new source were built by the town in 1892, and the use of water from Williston Pond has been discontinued. The new source of supply is Bassett Brook, a stream which rises in Northampton and flows into the Manhan River, just opposite the village of Easthampton. Water is taken from the brook a little less than a mile from its mouth, at a point where a low dam has been constructed forming a small basin. From the basin water flows by gravity, through a cast-iron pipe twelve inches in diameter, to a pumping station located at a dam on the Manhan River, a short distance below the mouth of Bassett Brook. From this point the water is pumped by water



**EASTHAMPTON.**

power, through a new cast-iron force main ten inches in diameter and one thousand two hundred and fifty feet in length, into the old system of distributing pipes in the village, the surplus water going to the distributing reservoir on Mt. Tom.

Bassett Brook, above the point of diversion, drains an area of about 6.9 square miles. In the upper portion of the watershed the slopes are steep, but in the middle and lower portions the surface is more nearly level, and there are considerable areas of flat land in the vicinity of the stream, some of which are swampy. There are no ponds or storage reservoirs on the watershed.

**WATER SUPPLY OF NORTH EASTON VILLAGE DISTRICT, EASTON.**

*Chemical Examination of Water from the Well of the North Easton Village District.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 11043   | 1893.<br>Sept. 18   | None.       | None.     | 0.0    | 3.90                    | .0000    | .0004       | .44       | .0200       | .0000     | .0234            | 1.2       | .0100 |

Odor, none. — The sample was collected from the well.

*Microscopical Examination.*

No organisms.

**WATER SUPPLY OF EVERETT.**

(See *Boston, Mystic Works.*)

**WATER SUPPLY OF FAIRHAVEN. — FAIRHAVEN WATER COMPANY.**

The advice of the State Board of Health to the Fairhaven Water Company with reference to the introduction of a water supply from tubular wells in the vicinity of the Nasketucket River will be found on page seventeen of this volume. Analyses of samples of water collected from wells near the river and from the river are given below.

## FAIRHAVEN.

The results found by analysis are somewhat remarkable, as they show that water from flowing wells only a short distance apart differed very much in quality, some of the water having its origin in a polluted source, and some of it being the natural water of the region. This subject is referred to quite fully in the advice of the Board. It is also worthy of note that there was a difference in the temperature of the water from wells driven to the same depth, that from the southerly well having a temperature, April 12, 1893, of 46.5 degrees, from the northerly well, 43 degrees, and from the middle wells, 48 degrees. The temperature of the water in the river at the same time was 55 degrees.

The works for taking water from this source were nearly completed at the end of 1893.

*Chemical Examination of Water from Tubular Test Wells in the Vicinity of the Nasketucket River, Fairhaven.*

[Parts per 100,000.]

| Number.  | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |          | Oxygen Consumed. | Hardness. | Iron. |
|----------|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|----------|------------------|-----------|-------|
|          |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrate.    | Nitrite. |                  |           |       |
| 10190    | 1893.<br>Mar. 30    | None.       | V. slight. | 0.02   | 10.15                   | .0002    | .0026       | 1.48      | .2200       | .0000    | .0146            | 3.1       | .0000 |
| 10247    | Apr. 12             | None.       | None.      | 0.00   | 3.90                    | .0000    | .0004       | 0.81      | .0480       | .0000    | .0182            | 1.3       | .0015 |
| 10248    | Apr. 12             | None.       | None.      | 0.00   | 12.60                   | .0000    | .0022       | 1.93      | .6000       | .0000    | .0146            | 3.9       | .0050 |
| Av. .... |                     |             |            | 0.01   | 8.88                    | .0001    | .0017       | 1.41      | .2893       | .0000    | .0158            | 2.8       | .0022 |

Odor, none. On heating, the odor of the first sample became faintly vegetable. — The wells are located in the vicinity of the river, about half a mile above the point where it is crossed by the Fairhaven branch of the N. Y., N. H. & H. R R. The first sample was collected from one of the middle wells in a line of six in the valley of the Nasketucket River; the second sample from the most northerly and the last from the most southerly well in this line.

*Microscopical Examination.*

No. 10190. Miscellaneous, Zoëglæa, 14.

## FAIRHAVEN.

*Chemical Examination of Water from the Nasketucket River, Fairhaven.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. | Oxygen Consumed. |           |
|         |                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 10249   | 1893.<br>Apr. 12    | V. slight.  | Slight.   | 1.90   | 5.55                            | 2.60                 | .0006    | .0228       | .0202      | .0026           | .71       | .0050          | .0001     | 1.3468           | 0.8       |

Iron, .0030. Odor, faintly vegetable. — The sample was collected from the river at the dam of a small ice pond, located a short distance above the test wells.

*Microscopical Examination.*

Diatomaceæ, *Melosira*, 3; *Meridion*, 11; *Navicula*, 5; *Nitzschia*, 1; *Pinnularia*, 1; *Synedra*, 34; *Tabellaria*, 44. Miscellaneous, *Zoëglæa*, 6. Total, 105.

### WATER SUPPLY OF FALMOUTH HEIGHTS. — FALMOUTH HEIGHTS WATER COMPANY.

This village is a summer resort on Vineyard Sound in the southerly part of the town of Falmouth. The source of supply is a well about ten feet in diameter and twenty feet in depth, located a short distance north-west of the village. Water is pumped from the well to an elevated wooden tank upon Observatory Hill in the village, and is thence distributed to consumers through cast-iron mains. The reply of the State Board of Health to the Falmouth Heights Water Company, with reference to the use of this well as a source of water supply for the village of Falmouth Heights, may be found on page 18 of this volume.

*Chemical Examination of Water from the Wells of the Falmouth Heights Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |                |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------------|----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.        | Sediment.      | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         |                     |                   |                |        |                         |          |             |           |             |           |                  |           |       |
| 10579   | 1893.<br>June 20    | Distinct, clayey. | Slight, white. | 0.0    | 6.40                    | .0000    | .0016       | 2.11      | .0000       | .0001     | .0474            | 1.7       | .0000 |

Odor, faintly earthy. — The sample was collected from the well.

*Microscopical Examination.*

No organisms.

## FITCHBURG.

## WATER SUPPLY OF FITCHBURG.

*Chemical Examination of Water from Scott Reservoir, Fitchburg.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                  |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.        | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |                  |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1893.   |                     |             |                  |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 10685   | July 19             | Slight.     | Slight.          | 0.10   | 2.60                            | 1.55                 | .0000    | .0332       | .0246      | .0086           | .15       | .0000          | .0001     | .3182            | 0.5       |
| 11203   | Oct. 16             | Decided.    | Cons.,<br>sandy. | 0.15   | 2.20                            | 1.15                 | .0000    | .0292       | .0180      | .0112           | .18       | .0000          | .0000     | .3483            | 0.2       |
| 11510   | Dec. 18             | None.       | V. slight.       | 0.04   | 3.25                            | 1.25                 | .0004    | .0076       | .0060      | .0016           | .19       | .0100          | .0000     | .1944            | 0.5       |
| Av.     | .....               | .....       | .....            | 0.10   | 2.68                            | 1.30                 | .0001    | .0233       | .0162      | .0071           | .17       | .0033          | .0000     | .2870            | 0.4       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 0.30 | 2.63 | 1.01 | .0007 | .0231 | -     | -     | .15 | .0021 | -     | -     | -   |
| - | 1888  | - | - | 0.11 | 2.31 | 0.79 | .0004 | .0240 | -     | -     | .13 | .0040 | .0001 | -     | -   |
| - | 1889  | - | - | 0.09 | 2.12 | 0.62 | .0008 | .0213 | .0162 | .0051 | .13 | .0030 | .0001 | -     | -   |
| - | 1890  | - | - | 0.10 | 2.54 | 1.02 | .0010 | .0217 | .0152 | .0065 | .13 | .0059 | .0001 | -     | 0.9 |
| - | 1891  | - | - | 0.13 | 2.55 | 1.05 | .0007 | .0146 | .0110 | .0036 | .14 | .0082 | .0000 | -     | 0.6 |
| - | 1892  | - | - | 0.13 | 2.78 | 1.16 | .0005 | .0261 | .0198 | .0063 | .18 | .0089 | .0000 | -     | 0.5 |
| - | 1893  | - | - | 0.10 | 2.68 | 1.30 | .0001 | .0233 | .0162 | .0071 | .17 | .0033 | .0000 | .2870 | 0.4 |

\* June to December.

NOTE to analyses of 1893: Iron, .0181. Odor of the first sample, distinctly unpleasant, becoming disagreeable on standing; of the other samples, faintly vegetable. — The samples were collected from the reservoir near the gate-house, one foot beneath the surface.

The heights of water in this reservoir on dates when samples of water were collected for analysis were as follows: July 19, thirty-seven feet; October 16, eighteen feet; December 18, twenty-nine feet. High-water mark is forty feet.

*Microscopical Examination of Water from Scott Reservoir, Fitchburg.*

[Number of organisms per cubic centimeter.]

|                               | 1893. |          |           |
|-------------------------------|-------|----------|-----------|
|                               | July. | October. | December. |
| Day of examination, . . . . . | 21    | 17       | 20        |
| Number of sample, . . . . .   | 10685 | 11203    | 11510     |
| <b>PLANTS.</b>                |       |          |           |
| Diatomaceæ, . . . . .         | 142   | 2,500    | 8         |
| Asterionella, . . . . .       | 15    | 36       | 0         |
| Diatoma, . . . . .            | 2     | 0        | 4         |
| Melosira, . . . . .           | 0     | 164      | 0         |
| Synedra, . . . . .            | 116   | 0        | 1         |
| Tabellaria, . . . . .         | 9     | 2,300    | 1         |

**FITCHBURG.***Microscopical Examination of Water from Scott Reservoir, Fitchburg—Concluded.*

[Number of organisms per cubic centimeter.]

|                                           | 1892. |          |           |
|-------------------------------------------|-------|----------|-----------|
|                                           | July. | October. | December. |
| <b>PLANTS—Con.</b>                        |       |          |           |
| Cyanophyceæ, <i>Anabæna</i> , . . . . .   | 0     | 3        | 0         |
| Algeæ, . . . . .                          | 5     | 1        | 0         |
| <i>Scenedesmus</i> , . . . . .            | 1     | 1        | 0         |
| <i>Staurostrum</i> , . . . . .            | 4     | 0        | 0         |
| Fungi, <i>Crenothrix</i> , . . . . .      | 0     | 9        | 0         |
| <b>ANIMALS.</b>                           |       |          |           |
| Rhizopoda, <i>Diffugia</i> , . . . . .    | 0     | 1        | 0         |
| Infusoria, . . . . .                      | 57    | 133      | 1         |
| Dinobryon cases, . . . . .                | 1     | 1        | 0         |
| <i>Peridinium</i> , . . . . .             | 56    | 132      | 1         |
| Vermes, . . . . .                         | 3     | 3        | 0         |
| <i>Anurea</i> , . . . . .                 | 2     | 3        | 0         |
| <i>Polyarthra</i> , . . . . .             | 1     | 0        | 0         |
| Miscellaneous, <i>Zoögkeæ</i> , . . . . . | 68    | 40       | 0         |
| <b>TOTAL</b> , . . . . .                  | 273   | 290      | 1         |

*Chemical Examination of Water from Meeting-house Pond, Westminster.*

| Number. | Date of Collection. | APPEARANCE.         |                  |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |        |             |                 |           | NITROGEN<br>AS |           | Oxygen Consumed. |     | Hardness. |
|---------|---------------------|---------------------|------------------|--------|---------------------------------|----------------------|----------|--------|-------------|-----------------|-----------|----------------|-----------|------------------|-----|-----------|
|         |                     | Turbidity.          | Sediment.        | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Total. | Albuminoid. |                 | Chlorine. | Nitrates.      | Nitrites. |                  |     |           |
|         |                     |                     |                  |        |                                 |                      |          |        | Dissolved.  | Sus-<br>pended. |           |                |           |                  |     |           |
| 1893.   |                     |                     |                  |        |                                 |                      |          |        |             |                 |           |                |           |                  |     |           |
| 9918    | Jan. 23             | V. slight.          | V. slight.       | 0.05   | 3.00                            | 1.15                 | .0018    | .0204  | .0172       | .0032           | .15       | .0000          | .0000     | .2737            | 0.7 |           |
| 10048   | Feb. 27             | None.               | V. slight.       | 0.08   | 2.50                            | 0.85                 | .0010    | .0124  | .0098       | .0026           | .21       | .0030          | .0001     | .2232            | 0.6 |           |
| 10152   | Mar. 20             | V. slight.          | Slight.          | 0.15   | 2.10                            | 0.90                 | .0036    | .0120  | .0110       | .0010           | .17       | .0000          | .0000     | .2376            | 0.6 |           |
| 10314   | Apr. 24             | V. slight.          | V. slight.       | 0.05   | 2.55                            | 0.80                 | .0006    | .0092  | .0062       | .0020           | .17       | .0070          | .0000     | .1934            | 0.6 |           |
| 10437   | May 22              | V. slight.          | Slight.          | 0.08   | 2.20                            | 0.85                 | .0006    | .0106  | .0086       | .0020           | .16       | .0000          | .0000     | .2587            | 0.3 |           |
| 10533   | June 19             | Distinct,<br>white. | Cons.,<br>white. | 0.08   | 1.90                            | 0.75                 | .0020    | .0156  | .0136       | .0020           | .18       | .0050          | .0000     | .2311            | 0.5 |           |
| 10684   | July 19             | V. slight.          | Slight.          | 0.05   | 2.25                            | 0.90                 | .0000    | .0178  | .0124       | .0054           | .14       | .0000          | .0000     | .1850            | 0.9 |           |
| 10883   | Aug. 22             | V. slight.          | V. slight.       | 0.08   | 2.15                            | 1.05                 | .0000    | .0116  | .0098       | .0018           | .16       | .0000          | .0000     | .2212            | 0.5 |           |
| 11051   | Sept. 19            | V. slight.          | V. slight.       | 0.05   | 2.30                            | 0.95                 | .0000    | .0142  | .0120       | .0022           | .19       | .0000          | .0000     | .2050            | 0.3 |           |
| 11292   | Oct. 16             | V. slight.          | V. slight.       | 0.02   | 2.65                            | 0.85                 | .0000    | .0224  | .0188       | .0036           | .17       | .0070          | .0000     | .2268            | 0.5 |           |
| 11377   | Nov. 23             | Slight.             | Slight.          | 0.05   | 2.45                            | 0.70                 | .0002    | .0056  | .0076       | .0010           | .17       | .0030          | .0000     | .2436            | 0.5 |           |
| 11511   | Dec. 18             | None.               | V. slight.       | 0.01   | 2.35                            | 0.85                 | .0008    | .0104  | .0084       | .0020           | .14       | .0020          | .0000     | .2349            | 0.5 |           |
| Av.     | .....               | .....               | .....            | 0.07   | 2.37                            | 0.88                 | .0009    | .0137  | .0113       | .0024           | .17       | .0023          | .0000     | .2304            | 0.6 |           |

Iron, .0020. Odor, generally faintly vegetable or none. — The samples were collected from the pond near the gate-house. Water was drawn regularly from this pond for the supply of the city during the year, with the exception of a short time in summer.

## FITCHBURG.

*Microscopical Examination of Water from Meeting-house Pond, Westminster.*

[Number of organisms per cubic centimeter.]

|                         | 1893. |       |       |       |       |       |       |       |       |       |       |       |
|-------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                         | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, .   | 25    | 28    | 23    | 26    | 24    | 21    | 21    | 25    | 20    | 17    | 24    | 20    |
| Number of sample, .     | 9018  | 10048 | 10152 | 10314 | 10437 | 10533 | 10684 | 10883 | 11051 | 11202 | 11377 | 11511 |
| PLANTS.                 |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . .         | 0     | 0     | 0     | 29    | 21    | 28    | 76    | 28    | 15    | 3     | 6     | 2     |
| Cyclotella, . .         | 0     | 0     | 0     | 1     | 3     | 0     | 3     | 7     | 1     | 0     | 6     | 1     |
| Melosira, . . .         | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 9     | 0     | 0     | 0     |
| Synedra, . . .          | pr.   | 0     | pr.   | 8     | 3     | 3     | 1     | 0     | pr.   | 0     | pr.   | 0     |
| Tabellaria, . .         | 0     | 0     | 0     | 20    | 15    | 25    | 72    | 21    | 5     | 3     | 0     | 1     |
| Cyanophyceæ, . .        | 0     | 0     | 0     | 0     | 0     | 1     | 68    | 1     | 13    | 10    | 0     | 0     |
| Anabaena, . . .         | 0     | 0     | 0     | 0     | 0     | 1     | 68    | 0     | 12    | pr.   | 0     | 0     |
| Microcystis, . .        | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 1     | 10    | 0     | 0     |
| ANIMALS.                |       |       |       |       |       |       |       |       |       |       |       |       |
| Rhizopoda,              |       |       |       |       |       |       |       |       |       |       |       |       |
| Actinophrys, . .        | 1     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Infusoria, . . .        | 23    | 21    | 0     | 92    | 1     | 0     | 2     | 2     | 34    | 4     | 0     | 0     |
| Cryptomonas, . .        | 18    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon, . . .        | 0     | 6     | 0     | 57    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, .      | 5     | 15    | 0     | 35    | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Peridinium, . . .       | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 2     | 34    | 4     | 0     | 0     |
| Miscellaneous, Zoöglaa, | 0     | 1     | 0     | 8     | 2     | 4     | 44    | 3     | 0     | 8     | 4     | 0     |
| TOTAL, . . . .          | 24    | 25    | pr.   | 129   | 24    | 33    | 190   | 34    | 62    | 25    | 10    | 2     |

*Chemical Examination of Water from Wyman's Reservoir, Fitchburg.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |  |
|---------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|--|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |  |
|         |                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |  |
| 1893.   |                     |             |           |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |  |
| 10686   | July 19             | Distinct.   | Cons. red | 1.30   | 4.20                            | 2.40                 | .0040    | .0476       | .0318      | .0158           | .11       | .0000          | .0001     | .8732            | 0.8       |  |
| 10884   | Aug. 22             | Slight.     | Slight.   | 1.40   | 4.00                            | 2.45                 | .0168    | .0342       | .0314      | .0028           | .15       | .0050          | .0000     | .9717            | 0.5       |  |

Iron, .0407. Odor of the first sample, musty and disagreeable, becoming offensive on heating; of the second sample, none, becoming faintly vegetable on heating. — The samples were collected from the end of the pipe below the gate-house, and represent water drawn from the bottom of the reservoir. This reservoir is not used as a source of water supply, although it is owned by the city and is within the territory from which it is authorized to take water.

*Microscopical Examination.*

No. 10686. Diatomaceæ, *Synedra*, 80. Fungi, *Crenothrix*, 60. Infusoria, *Dinobryon cases*, 1. Vermes, *Anurea*, 3. Miscellaneous, *Zoöglaa*, 380. Total, 524.

No. 10884. Diatomaceæ, *Cyclotella*, 1; *Synedra*, 5; *Tabellaria*, 3. Algæ, *Chlorococcus*, 4; *Closterium*, 3; *Raphidium*, 3. Fungi, *Crenothrix*, 3. Infusoria, *Dinobryon cases*, 3; *Peridinium*, 4; *Trachelomonas*, 1. Vermes, *Anurea*, pr. Total, 30.

## CLINTON.

*Microscopical Examination of Water from the Clinton Water Works—Concluded.*

[Number of organisms per cubic centimeter.]

|                             | 1895. |      |      |      |      |      |      |      |
|-----------------------------|-------|------|------|------|------|------|------|------|
|                             | Aug.  | Dec. | Aug. | Dec. | Dec. | Aug. | Dec. | Dec. |
| PLANTS—Con.                 |       |      |      |      |      |      |      |      |
| Cyanophyceæ, . . . .        | 542   | 1    | 0    | 0    | 0    | 0    | 0    | 0    |
| Aphanocapsa, . . . .        | 2     | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Merismopedia, . . . .       | 540   | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Oscillaria, . . . .         | 0     | 1    | 0    | 0    | 0    | 0    | 0    | 0    |
| Algæ, . . . .               | 422   | 0    | 60   | 1    | 1    | 7    | 1    | 0    |
| Arthrodesmus, . . . .       | 0     | 0    | 9    | 0    | 0    | 0    | 0    | 0    |
| Chlorococcus, . . . .       | 1     | 0    | 1    | 0    | 0    | 0    | 0    | 0    |
| Cosmarium, . . . .          | 1     | 0    | 1    | 0    | 0    | 2    | 0    | 0    |
| Desmidiun, . . . .          | 7     | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Eudorina, . . . .           | 2     | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Glæocapsa, . . . .          | 52    | 0    | 1    | 0    | 0    | 0    | 0    | 0    |
| Pandorina, . . . .          | 0     | 0    | 0    | 1    | 0    | 0    | 0    | 0    |
| Protoroccus, . . . .        | 328   | 0    | 25   | 0    | 0    | 0    | 0    | 0    |
| Raphidium, . . . .          | 2     | 0    | 3    | 0    | 0    | 0    | 0    | 0    |
| Scenedesmus, . . . .        | 26    | 0    | 16   | 0    | 1    | 1    | 1    | 0    |
| Spirogyra, . . . .          | 2     | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Staurastrum, . . . .        | 2     | 0    | 2    | 0    | 0    | 4    | 0    | 0    |
| Stauroneis, . . . .         | 0     | 0    | 2    | 0    | 0    | 0    | 0    | 0    |
| Fungi, Crenothrix, . . . .  | 76    | 1    | 0    | 1    | 2    | 0    | 0    | 0    |
| ANIMALS.                    |       |      |      |      |      |      |      |      |
| Rhizopoda, Actinophrys, . . | 1     | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Infusoria, . . . .          | 37    | 26   | 63   | 68   | 4    | 79   | 6    | 0    |
| Dinobryon, . . . .          | 0     | 19   | 0    | 68   | 1    | 0    | 0    | 0    |
| Dinobryon cases, . . . .    | 1     | 0    | 56   | 0    | 0    | 76   | 0    | 0    |
| Monas, . . . .              | 2     | 0    | 0    | 0    | 0    | 2    | 0    | 0    |
| Peridinium, . . . .         | 28    | 7    | 13   | 0    | 3    | 0    | 5    | 0    |
| Trachelomonas, . . . .      | 6     | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Uroglena, . . . .           | 0     | 0    | 0    | 0    | 0    | 0    | 0    | 1    |
| Vorticella, . . . .         | 1     | 0    | 0    | 0    | 0    | 1    | 0    | 0    |
| Vermes, . . . .             | 18    | 0    | 4    | 0    | 1    | 6    | 2    | 0    |
| Anurea, . . . .             | 7     | 0    | 1    | 0    | 0    | 0    | 0    | 0    |
| Polyarthra, . . . .         | 8     | 0    | 0    | 0    | 1    | 3    | 0    | 0    |
| Rotatorian ova, . . . .     | 3     | 0    | 3    | 0    | 0    | 2    | 0    | 0    |
| Rotifer, . . . .            | 0     | 0    | 0    | 0    | 0    | 0    | 2    | 0    |
| Miscellaneous, . . . .      |       |      |      |      |      |      |      |      |
| Acarina, . . . .            | .02   | 0    | 0    | 0    | 0    | 0    | .02  | 0    |
| Zoëglæa, . . . .            | 128   | 0    | 84   | 0    | 0    | 0    | 0    | 0    |
| TOTAL, . . . .              | 1,462 | 31   | 455  | 138  | 61   | 127  | 56   | 42   |

**WATER SUPPLY OF COHASSET. — COHASSET WATER COMPANY.**

The advice of the State Board of Health to the Cohasset Water Company relative to increasing its water supply may be found on page 17 of this volume. Analyses of water from present sources of supply and of samples collected during the investigations for an additional water supply are given on succeeding pages.

## FRAMINGHAM.

*Chemical Examination of Water from a Faucet in South Framingham, supplied from the Works of the Framingham Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.     |                  |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-----------------|------------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.      | Sediment.        | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 1893.   |                     |                 |                  |        |                         |          |             |           |             |           |                  |           |       |
| 10016   | Feb. 14             | None.           | None.            | 0.02   | 5.70                    | .0000    | .0058       | .56       | .0250       | .0002     | .0022            | 3.3       | .0100 |
| 10244   | Apr. 11             | None.           | V. slight.       | 0.02   | 6.00                    | .0008    | .0028       | .49       | .0500       | .0005     | .0547            | 2.5       | .0025 |
| 10512   | June 13             | None.           | None.            | 0.01   | 5.90                    | .0000    | .0062       | .39       | .0250       | .0000     | .0636            | 2.2       | .0025 |
| 10799   | Aug. 15             | Decided, milky. | Cons., rusty.    | 0.05   | 5.20                    | .0208    | .0054       | .70       | .0000       | .0000     | .1422            | 1.9       | .1200 |
| 11170   | Oct. 11             | V. slight.      | Slight, fibrous. | 0.05   | 6.70                    | .0000    | .0020       | .71       | .0400       | .0000     | .1174            | 3.0       | .0210 |
| 11478   | Dec. 12             | None.           | None.            | 0.00   | 6.25                    | .0002    | .0008       | .62       | .0380       | .0000     | .0840            | 5.0       | .0070 |
| Av.     | .....               | .....           | .....            | 0.03   | 5.96                    | .0036    | .0038       | .58       | .0207       | .0001     | .0923            | 2.7       | .0272 |

Odor of No. 10799, like tar; of the others, none. — The samples were collected from a faucet at the works of the Gosamer Rubber Company, which are located near the end of the distributing system just south of the Boston and Albany Railroad about a mile west of South Framingham and a little over two miles from the pumping station by way of the pipe line.

## Microscopical Examination.

No. 10799, Miscellaneous, *Zoëglæa*, 1126.

No. 11170, Fungi, *Orenothrix*, 78. Miscellaneous, *Zoëglæa*, 6. Total, 84.

No. 11478, Diatomaceæ, *Melosira*, 3. Fungi, *Orenothrix*, 1. Infusoria, *Peridinium*, 1. Total, 5.

No organisms were found in the remaining samples.

*Chemical Examination of Water from the Underdrain beneath the Sewers at Framingham.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| -       | 1893.               |             |           |        |                         |          |                  |           |             |           |                  |           |       |
| -       | Jan. 14             | V. slight.  | Cons.     | 0.02   | 20.10                   | .0840    | .0050            | 4.20      | .6250       | .0015     | .0800            | 7.4       | -     |
| -       | Feb. 14             | V. slight.  | Cons.     | 0.02   | 18.90                   | .0660    | .0060            | 3.70      | .6000       | .0013     | .0500            | 7.8       | -     |
| -       | Mar. 14             | Slight.     | Slight.   | 0.00   | 18.70                   | .0840    | .0060            | 3.15      | .6000       | .0010     | .0400            | 7.3       | -     |
| -       | Apr. 14             | V. slight.  | Slight.   | 0.01   | 20.30                   | .0960    | .0040            | 3.65      | .6750       | .0010     | .0800            | 7.5       | -     |
| -       | May 18              | V. slight.  | Slight.   | 0.02   | 17.50                   | .0880    | .0050            | 3.20      | .7600       | .0012     | .0500            | 7.4       | -     |
| -       | June 13             | V. slight.  | Slight.   | 0.02   | 21.00                   | .0920    | .0030            | 4.15      | .7500       | .0010     | .0600            | 7.5       | -     |
| -       | July 14             | V. slight.  | Slight.   | 0.01   | 24.60                   | .0800    | .0030            | 4.45      | .6250       | .0011     | .0400            | 7.6       | -     |
| -       | Aug. 14             | None.       | Slight.   | 0.02   | 20.40                   | .0720    | .0020            | 3.95      | .6000       | .0010     | .0600            | 7.5       | -     |
| -       | Oct. 15             | V. slight.  | Slight.   | 0.02   | 24.20                   | .0760    | .0020            | 4.35      | .6250       | .0018     | .1000            | 7.7       | -     |
| -       | Nov. 14             | V. slight.  | Slight.   | 0.02   | 22.70                   | .0760    | .0030            | 4.00      | .5400       | .0025     | .0900            | 7.1       | -     |
| -       | Dec. 12             | V. slight.  | Slight.   | 0.02   | 19.90                   | .0678    | .0040            | 3.45      | .5200       | .0023     | .0700            | 6.9       | -     |
| Av.     |                     |             |           | 0.02   | 20.75                   | .0829    | .0039            | 3.84      | .6282       | .0014     | .0645            | 7.4       | -     |

## Averages of Analyses of Previous Years.

|   |       |   |   |      |       |       |       |      |       |       |       |     |   |
|---|-------|---|---|------|-------|-------|-------|------|-------|-------|-------|-----|---|
| - | 1889* | - | - | 0.00 | 19.70 | .0800 | .0080 | 3.73 | .4750 | .0045 | -     | 6.6 | - |
| - | 1890  | - | - | 0.01 | 19.71 | .0824 | .0073 | 3.51 | .5336 | .0026 | -     | 8.4 | - |
| - | 1891  | - | - | 0.01 | 20.44 | .1029 | .0045 | 3.51 | .5333 | .0019 | -     | 8.0 | - |
| - | 1892  | - | - | 0.01 | 19.32 | .0805 | .0042 | 3.99 | .6667 | .0018 | -     | 8.0 | - |
| - | 1893  | - | - | 0.02 | 20.75 | .0829 | .0039 | 3.84 | .6282 | .0014 | .0645 | 7.4 | - |

\* October.

Note to analyses of 1893: Odor, generally faintly vegetable and mouldy. — The samples were collected from the underdrain at its outlet.

The analysis of 1899 was made before sewage was admitted to the sewers. Several of the analyses made in 1890 and all of those of subsequent years were made by the city of Boston.



## GARDNER.

## WATER SUPPLY OF GARDNER. — GARDNER WATER COMPANY.

*Chemical Examination of Water from Crystal Lake, Gardner.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |           |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|-----------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |           |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved | Sus-<br>pended. |           |                |           |                  |           |
| 9896    | 1893.<br>Jan. 18    | V. slight.  | V. slight. | 0.03   | 2.90                            | 0.90                 | .0006    | .0116       | .0098     | .0018           | .32       | .0000          | .0000     | .1700            | 0.8       |
| 10037   | Feb. 21             | Slight.     | V. slight. | 0.05   | 2.45                            | 0.85                 | .0012    | .0116       | .0096     | .0020           | .35       | .0060          | .0000     | .2497            | 1.3       |
| 10135   | Mar. 16             | Slight.     | Slight.    | 0.08   | 2.85                            | 0.80                 | .0002    | .0146       | .0116     | .0030           | .40       | .0050          | .0001     | .2376            | 0.9       |
| 10268   | Apr. 19             | Slight.     | Slight.    | 0.03   | 2.55                            | 0.55                 | .0004    | .0114       | .0096     | .0018           | .26       | .0050          | .0001     | .1569            | 0.8       |
| 10397   | May 16              | Slight.     | V. slight. | 0.05   | 2.75                            | 0.85                 | .0004    | .0126       | .0106     | .0020           | .18       | .0050          | .0000     | .1934            | 0.9       |
| 10517   | June 13             | Distinct.   | Cons.      | 0.05   | 2.95                            | 0.95                 | .0000    | .0172       | .0126     | .0046           | .27       | .0000          | .0000     | .1507            | 0.8       |
| 10567   | June 26             | Slight.     | Slight.    | 0.02   | 2.65                            | 1.25                 | .0004    | .0246       | .0228     | .0018           | .28       | .0000          | .0000     | .1580            | 0.5       |
| 10662   | July 14             | V. slight.  | Slight.    | 0.03   | 2.50                            | 1.05                 | .0008    | .0158       | .0122     | .0036           | .22       | .0000          | .0000     | .1971            | 0.8       |
| 10813   | Aug. 15             | Slight.     | Slight.    | 0.05   | 2.45                            | 0.65                 | .0000    | .0120       | .0102     | .0018           | .26       | .0000          | .0000     | .1856            | 0.8       |
| 11016   | Sept. 12            | V. slight.  | V. slight. | 0.02   | 2.55                            | 0.85                 | .0000    | .0108       | .0090     | .0018           | .25       | .0000          | .0000     | .1755            | 0.5       |
| 11207   | Oct. 17             | V. slight.  | V. slight. | 0.03   | 2.85                            | 1.00                 | .0000    | .0114       | .0104     | .0010           | .26       | .0000          | .0000     | .1620            | 0.5       |
| 11332   | Nov. 14             | V. slight.  | V. slight. | 0.10   | 2.55                            | 0.55                 | .0006    | .0080       | .0062     | .0018           | .26       | .0020          | .0000     | .2282            | 0.8       |
| 11472   | Dec. 11             | Slight.     | Slight.    | 0.04   | 2.70                            | 0.65                 | .0010    | .0108       | .0086     | .0022           | .26       | .0020          | .0000     | .1440            | 1.1       |
| * Av.   | .....               | .....       | .....      | 0.05   | 2.65                            | 0.82                 | .0012    | .0126       | .0105     | .0021           | .27       | .0021          | .0000     | .1879            | 0.8       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887† | - | - | 0.02 | 2.63 | 0.62 | .0006 | .0111 | -     | -     | .21 | .0019 | -     | -     | -   |
| - | 1888‡ | - | - | 0.01 | 2.60 | 0.62 | .0023 | .0112 | -     | -     | .22 | .0094 | .0001 | -     | -   |
| - | 1891§ | - | - | 0.02 | 2.95 | 0.85 | .0007 | .0119 | .0298 | .0021 | .16 | .0073 | .0001 | 0.7   | -   |
| - | 1892  | - | - | 0.02 | 2.45 | 0.65 | .0008 | .0104 | .0086 | .0018 | .27 | .0180 | .0000 | 1.1   | -   |
| - | 1893  | - | - | 0.05 | 2.65 | 0.82 | .0012 | .0126 | .0105 | .0021 | .27 | .0021 | .0000 | .1879 | 0.8 |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

† June to December.

‡ January to May.

§ June, three samples.

|| March.

NOTE to analyses of 1893: Iron, .0054. Odor, generally faintly vegetable or none; in June the odor became disagreeable and oily on heating the water. — The first five samples were collected from a faucet at the pumping station while pumping. No. 10567 was collected directly from the lake. The remaining samples were collected from a faucet in the town.

GARDNER.

*Microscopical Examination of Water from Crystal Lake, Gardner.*

[Number of organisms per cubic centimeter.]

|                          | 1893. |       |       |       |       |       |       |       |       |       |       |       |       |
|--------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                          | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, .    | 20    | 23    | 17    | 20    | 17    | 14    | 28    | 15    | 16    | 14    | 19    | 15    | 12    |
| Number of sample, .      | 9896  | 10037 | 10135 | 10268 | 10397 | 10517 | 10567 | 10662 | 10813 | 11016 | 11207 | 11332 | 11472 |
| PLANTS.                  |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, .            | 34    | 1     | 0     | 33    | 166   | 675   | 180   | 45    | 5     | 0     | pr.   | 8     | 170   |
| Asterionella, .          | 0     | 0     | 0     | 7     | 160   | 32    | 0     | 0     | 2     | 0     | 0     | 3     | 0     |
| Cyclotella, .            | 34    | 0     | 0     | 1     | 20    | 580   | 180   | 30    | 1     | 0     | pr.   | 4     | 12    |
| Fragilaria, .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 16    |
| Melosira, .              | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 142   |
| Synedra, .               | 0     | 1     | 0     | 24    | 3     | 52    | pr.   | 16    | 0     | 0     | pr.   | 0     | 0     |
| Tabellaria, .            | 0     | 0     | 0     | 1     | 3     | 11    | 0     | 0     | 2     | 0     | pr.   | 1     | 0     |
| Cyanophyceæ, .           | 0     | 0     | 0     | 0     | 0     | 0     | 18    | 3     | 1     | 0     | 84    | 1     | 0     |
| Chroococcus, .           | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 84    | 1     | 0     |
| Cælospherium, .          | 0     | 0     | 0     | 0     | 0     | 0     | 18    | 3     | 1     | 0     | 0     | 0     | 0     |
| Algæ, . . . .            | 8     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 6     | 0     | 0     | 12    | 46    |
| Botryococcus, .          | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 7     | 0     |
| Protooccus, .            | 8     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 6     | 0     | 0     | 5     | 0     |
| Raphidium, .             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 46    |
| ANIMALS.                 |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . .           | 4     | 122   | 1     | 62    | 48    | 9     | 52    | 42    | 2     | 0     | 122   | 28    | 64    |
| Dinobryon, .             | 0     | 94    | 0     | 22    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 55    |
| Dinobryon cases, .       | 4     | 28    | 0     | 40    | 48    | 6     | 0     | pr.   | 0     | 0     | 122   | 23    | 9     |
| Monas, . . .             | 0     | 0     | 0     | 0     | 0     | 1     | 0     | pr.   | 0     | 0     | 0     | 3     | 0     |
| Peridinium, .            | 0     | pr.   | 1     | 0     | pr.   | 0     | 52    | 42    | 2     | 0     | pr.   | pr.   | pr.   |
| Trachelomonas, .         | 0     | 0     | 0     | 0     | 0     | 2     | pr.   | 0     | pr.   | 0     | 0     | 0     | 0     |
| Vermes, . . .            | 0     | pr.   | 0     | 0     | 1     | 1     | 0     | pr.   | pr.   | 0     | pr.   | pr.   | 0     |
| Anura, . . .             | 0     | pr.   | 0     | 0     | 1     | 0     | 0     | pr.   | 0     | 0     | pr.   | pr.   | 0     |
| Rotatorian ova, .        | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 0     | pr.   | 0     | 0     | pr.   | 0     |
| Miscellaneous, Zoöglonæ, | 0     | 8     | 22    | 0     | 8     | 60    | 2     | 22    | 2     | 32    | 2     | 16    | 2     |
| TOTAL, . . .             | 46    | 131   | 23    | 95    | 243   | 745   | 252   | 113   | 16    | 32    | 208   | 66    | 282   |

## CONCORD AND LINCOLN.

*Microscopical Examination of Water from Sandy Pond, Lincoln.*

[Number of organisms per cubic centimeter.]

|                                      | 1895.     |        |        |         |
|--------------------------------------|-----------|--------|--------|---------|
|                                      | February. | March. | April. | August. |
| Day of examination, . . . . .        | 16        | 14     | 9      | 20      |
| Number of sample, . . . . .          | 13824     | 13963  | 14102  | 14955   |
| <b>PLANTS.</b>                       |           |        |        |         |
| Diatomaceæ, . . . . .                | 0         | 0      | 2      | 20      |
| Cyclotella, . . . . .                | 0         | 0      | 0      | 6       |
| Melosira, . . . . .                  | 0         | 0      | 0      | 2       |
| Synedra, . . . . .                   | 0         | 0      | 2      | 11      |
| Tabellaria, . . . . .                | 0         | 0      | 0      | 2       |
| Cyanophyceæ, Merismopedia, . . . . . | 0         | 0      | 0      | 10      |
| Algeæ, . . . . .                     | 0         | 0      | 0      | 24      |
| Pediastrum, . . . . .                | 0         | 0      | 0      | 6       |
| Protopoccus, . . . . .               | 0         | 0      | 0      | 11      |
| Raphidium, . . . . .                 | 0         | 0      | 0      | 2       |
| Scenedesmus, . . . . .               | 0         | 0      | 0      | 2       |
| Zoopores, . . . . .                  | 0         | 0      | 0      | 2       |
| Fungi, Crenothrix, . . . . .         | 0         | 2      | 2      | 0       |
| <b>ANIMALS.</b>                      |           |        |        |         |
| Infusoria, . . . . .                 | 152       | 57     | 38     | 15      |
| Dinobryon, . . . . .                 | 76        | 1      | 30     | 0       |
| Dinobryon cases, . . . . .           | 76        | 56     | 8      | 0       |
| Monas, . . . . .                     | 0         | 0      | 0      | 1       |
| Peridinium, . . . . .                | 0         | 0      | pr.    | 14      |
| Miscellaneous, Zoöglæa, . . . . .    | 0         | 0      | 0      | 24      |
| TOTAL, . . . . .                     | 152       | 59     | 42     | 108     |

HANSON.

## HANSON.

*Chemical Examination of Water from Maquam Pond, Hanson.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 10335   | 1893.<br>Apr. 29    | V. slight.  | Slight.   | 0.02   | 2.35                    | 0.85              | .0002    | .0148       | .0124      | .0024      | .54       | .0000       | .0000     | .1314            | 0.3       |

Iron, none. Odor, distinctly vegetable and disagreeable, becoming faintly vegetable on heating. — The sample was collected from the pond at its northerly end, near the shore.

Reference is made to the quality of this water in a reply of the State Board of Health to the town of Whitman with regard to taking a water supply for the town from this pond and from other sources in the vicinity, which may be found on page 67 of this volume

*Microscopical Examination.*

Diatomaceæ, *Melosira*, 2; *Synedra*, 1; *Tabellaria*, 9. Algæ, *Ulothrix*, 1. Infusoria, *Dinobryon*, 2; *Dinobryon cuneis*, 32; *Peridinium*, 792. Total, 839.

## WATER SUPPLY OF HAVERHILL.

*Chemical Examination of Water from Crystal Lake, Haverhill.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                  |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. |           |
|---------|---------------------|-------------|------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.        | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. | Oxygen Consumed. | Hardness. |
|         |                     |             |                  |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 10028   | 1893.<br>Feb. 15    | Slight.     | V. slight.       | 0.20   | 2.55                            | 1.10                 | .0000    | .0170       | .0150      | .0020           | .27       | .0000          | .0000     | .4222            | 1.3       |
| 10526   | June 19             | Slight.     | Cons.,<br>brown. | 0.40   | 2.80                            | 1.10                 | .0008    | .0218       | .0160      | .0058           | .24       | .0030          | .0000     | .3383            | 0.9       |
| 11217   | Oct. 17             | Slight.     | Slight.          | 0.18   | 2.85                            | 1.15                 | .0000    | .0158       | .0140      | .0018           | .22       | .0030          | .0000     | .3402            | 0.8       |
| Av.     | .....               | .....       | .....            | 0.26   | 2.73                            | 1.12                 | .0003    | .0182       | .0150      | .0032           | .24       | .0020          | .0000     | .3669            | 1.0       |

Iron, .0045. Odor of the first sample, very disagreeable, disappearing on heating; of the second sample, vegetable; of the last, very faintly vegetable, becoming stronger and grassy on heating. — The first and last samples were collected directly from Crystal Lake; the second sample, from a faucet in the city supplied from Crystal Lake.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in these samples was as follows: In February, 8; in June, 311; in October, 56.

**HAVERHILL.***Chemical Examination of Water from Kenoza Lake, Haverhill.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                  |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.        | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                  |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 10030   | 1893.<br>Feb. 15    | Slight.     | Slight.          | 0.15   | 3.75                    | 1.30              | .0032    | .0234       | .0168      | .0066      | .50       | .0030       | .0000     | .3322            | 1.7       |
| 10529   | June 19             | Slight.     | Slight.          | 0.05   | 3.45                    | 1.10              | .0006    | .0206       | .0172      | .0034      | .36       | .0000       | .0000     | .2077            | 1.6       |
| 11216   | Oct. 17             | Slight.     | Slight.<br>gray. | 0.08   | 3.45                    | 0.95              | .0000    | .0166       | .0148      | .0018      | .36       | .0000       | .0000     | .2430            | 1.6       |
| Av.     | .....               | .....       | .....            | 0.09   | 3.55                    | 1.12              | .0013    | .0202       | .0163      | .0039      | .41       | .0010       | .0000     | .2610            | 1.6       |

Iron, .0052. Odor, vegetable and unpleasant in the first two samples; faintly vegetable in the last. The odor diminished on heating. — The samples were collected from the lake.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: in February, 192; in June, 66; in October, 437.

*Chemical Examination of Water from Lake Saltonstall, Haverhill.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1893.   |                     |             |                |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 10029   | Feb. 15             | Slight.     | V. slight.     | 0.10   | 4.50                    | 1.10              | .0120    | .0226       | .0194      | .0032      | .47       | .0030       | .0000     | .3097            | 2.1       |
| 10527   | June 19             | Slight.     | Slight, brown. | 0.08   | 5.10                    | 1.35              | .0012    | .0216       | .0186      | .0030      | .65       | .0030       | .0000     | .1809            | 2.2       |
| 11214   | Oct. 17             | Slight.     | Slight.        | 0.10   | 5.70                    | 1.85              | .0020    | .0174       | .0154      | .0020      | .64       | .0030       | .0000     | .2592            | 2.2       |
| Av.     | .....               | .....       | .....          | 0.09   | 5.10                    | 1.43              | .0051    | .0205       | .0178      | .0027      | .59       | .0030       | .0000     | .2499            | 2.2       |

Iron, .0067. Odor of the first sample, distinctly vegetable and unpleasant; of the second sample, faintly vegetable, becoming stronger and unpleasant on heating; of the last sample, very faintly vegetable, becoming much stronger and grassy on heating. — The samples were collected from the lake.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: in February, 4; in June, 191; in October, 300.

## HAVERHILL.

*Chemical Examination of Water from Lake Pentucket, Haverhill.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                  |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. |           |
|---------|---------------------|-------------|------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.        | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. | Oxygen Consumed. | Hardness. |
|         |                     |             |                  |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
|         | <b>1893.</b>        |             |                  |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 10027   | Feb. 15             | Slight.     | Slight.          | 0.08   | 3.45                            | 1.10                 | .0012    | .0178       | .0140      | .0038           | .38       | .0000          | .0000     | .2572            | 1.7       |
| 10528   | June 19             | Slight.     | Cons.,<br>brown. | 0.08   | 3.30                            | 1.05                 | .0006    | .0218       | .0166      | .0052           | .38       | .0000          | .0000     | .1809            | 1.3       |
| 11215   | Oct. 17             | V.slight.   | Slight.          | 0.05   | 3.55                            | 1.05                 | .0010    | .0200       | .0174      | .0026           | .36       | .0000          | .0000     | .2227            | 1.4       |
| Av.     | .....               | .....       | .....            | 0.07   | 3.43                            | 1.07                 | .0009    | .0199       | .0160      | .0039           | .37       | .0000          | .0000     | .2203            | 1.5       |

Iron, .0048. Odor, vegetable, stronger in the second sample than in the other two. — The samples were collected from the lake.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: in February, 36; in June, 29; in October, 32.

## WATER SUPPLY OF HINGHAM AND HULL. — HINGHAM WATER COMPANY.

*Chemical Examination of Water from Accord Pond, Hingham.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
|         | 1893.               |             |            |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 10158   | Mar. 22             | Slight.     | Slight.    | 0.20   | 2.95                    | 1.00              | .0004    | .0082       | .0058      | .0024      | .62       | .0000       | .0000     | .2923            | 0.5       |
| 10548   | June 21             | V. slight.  | V. slight. | 0.20   | 3.55                    | 1.80              | .0004    | .0144       | .0128      | .0016      | .58       | .0030       | .0001     | .3239            | 0.2       |
| 10760   | Aug. 9              | V. slight.  | Slight.    | 0.20   | 3.00                    | 1.10              | .0006    | .0112       | .0092      | .0020      | .65       | .0050       | .0000     | .2646            | 0.6       |
| 11072   | Sept. 20            | V. slight.  | V. slight. | 0.10   | 2.75                    | 0.25              | .0000    | .0144       | .0124      | .0020      | .66       | .0050       | .0000     | .2911            | 0.3       |
| 11516   | Dec. 18             | V. slight.  | V. slight. | 0.10   | 2.85                    | 0.85              | .0000    | .0124       | .0114      | .0010      | .64       | .0030       | .0000     | .2875            | 0.1       |
| Av.     | .....               | .....       | .....      | 0.16   | 3.02                    | 1.00              | .0003    | .0121       | .0103      | .0018      | .63       | .0032       | .0000     | .2919            | 0.3       |

Iron, .0043. Odor of the first sample, none, becoming vegetable on standing; of the second sample, decidedly vegetable; of the third sample, faintly vegetable; of the remaining samples, none. — Sample No. 10760 was collected from the pump well at the pumping station; the remaining samples from the pond near the surface.

## HINGHAM.

*Microscopical Examination of Water from Accord Pond, Hingham.*

[Number of organisms per cubic centimeter.]

|                                   | 1893.  |       |         |            |           |
|-----------------------------------|--------|-------|---------|------------|-----------|
|                                   | March. | June. | August. | September. | December. |
| Day of examination, . . . . .     | 24     | 22    | 10      | 22         | 20        |
| Number of sample, . . . . .       | 10158  | 10548 | 10760   | 11072      | 11516     |
| <b>PLANTS.</b>                    |        |       |         |            |           |
| Diatomaceæ, . . . . .             | 17     | 18    | 5       | 1,886      | 38        |
| Asterionella, . . . . .           | 4      | 0     | 0       | 0          | 0         |
| Cyclotella, . . . . .             | 0      | 14    | 1       | 0          | 1         |
| Melosira, . . . . .               | 0      | 0     | 2       | 1,880      | 0         |
| Navicula, . . . . .               | 0      | 0     | pr.     | 4          | 0         |
| Synedra, . . . . .                | 4      | 1     | 2       | 2          | 25        |
| Tabellaria, . . . . .             | 9      | 1     | 0       | 0          | 12        |
| Cyanophyceæ, . . . . .            | 0      | 48    | 8       | 156        | 0         |
| Anabæna, . . . . .                | 0      | pr.   | 5       | 100        | 0         |
| Anabæna spores, . . . . .         | 0      | 0     | 0       | 66         | 0         |
| Cælospærium, . . . . .            | 0      | 32    | 0       | 0          | 0         |
| Merismopodia, . . . . .           | 0      | 14    | 0       | 0          | 0         |
| Microcystis, . . . . .            | 0      | 0     | 3       | 0          | 0         |
| Algæ, . . . . .                   | 0      | 4     | 38      | 10         | 0         |
| Nephrocytium, . . . . .           | 0      | 0     | 0       | 4          | 0         |
| Pediastrum, . . . . .             | 0      | 0     | 0       | 3          | 0         |
| Raphidium, . . . . .              | 0      | 4     | 38      | 0          | 0         |
| Scenedesmus, . . . . .            | 0      | 0     | 0       | 3          | 0         |
| Fungi, Crenothrix, . . . . .      | 0      | 0     | pr.     | 36         | 0         |
| <b>ANIMALS.</b>                   |        |       |         |            |           |
| Infusoria, . . . . .              | 0      | 0     | 4       | 27         | 3         |
| Dinobryon cases, . . . . .        | 0      | 0     | pr.     | 0          | 3         |
| Monas, . . . . .                  | 0      | 0     | 0       | 24         | 0         |
| Peridinium, . . . . .             | 0      | pr.   | 4       | 3          | 0         |
| Vermes, . . . . .                 | 0      | 0     | 0       | 4          | 0         |
| Anurea, . . . . .                 | 0      | 0     | 0       | 1          | 0         |
| Polyarthra, . . . . .             | 0      | 0     | 0       | 2          | 0         |
| Rotifer, . . . . .                | 0      | 0     | 0       | 1          | 0         |
| Miscellaneous, Zoöglæa, . . . . . | 0      | 0     | 28      | 0          | 2         |
| TOTAL, . . . . .                  | 17     | 66    | 81      | 2,119      | 43        |

## HINGHAM.

*Chemical Examination of Water from Fulling Mill Pond, Hingham.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |            |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. |     | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|------------|------------|-----------------|-----------|----------------|-----------|------------------|-----|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid |            |                 |           | Nitrates.      | Nitrites. |                  |     |           |
|         |                     |             |            |        |                                 |                      |          | Total.     | Dissolved. | Sus-<br>pended. |           |                |           |                  |     |           |
| 1893.   |                     |             |            |        |                                 |                      |          |            |            |                 |           |                |           |                  |     |           |
| 10157   | Mar. 22             | Distinct.   | Cons.      | 0.43   | 3.80                            | 1.15                 | .0006    | .0150      | .0076      | .0074           | .70       | .0000          | .0000     | .3816            | 1.3 |           |
| 10547   | June 21             | V. slight.  | Cons.      | 0.05   | 4.80                            | 1.40                 | .0000    | .0048      | .0024      | .0024           | .59       | .0200          | .0001     | .1066            | 1.1 |           |
| 11073   | Sept. 20            | Decided.    | Slight.    | 0.12   | 4.80                            | 0.75                 | .0008    | .0560      | .0264      | .0206           | .66       | .0030          | .0001     | .3731            | 1.1 |           |
| 11515   | Dec. 18             | Slight.     | V. slight. | 0.30   | 4.60                            | 2.00                 | .0010    | .0134      | .0108      | .0026           | .72       | .0080          | .0000     | .4090            | 1.4 |           |
| Av.     | .....               | .....       | .....      | 0.23   | 4.50                            | 1.33                 | .0006    | .0223      | .0118      | .0105           | .67       | .0078          | .0001     | .3176            | 1.2 |           |

Iron, .0081. Odor, vegetable or none. The odor of No. 11073 became disagreeable on heating. — The samples were collected from the pond near the surface.

*Microscopical Examination of Water from Fulling Mill Pond, Hingham.*

[Number of organisms per cubic centimeter.]

|                                     | <b>1893.</b> |       |            |           |
|-------------------------------------|--------------|-------|------------|-----------|
|                                     | March.       | June. | September. | December. |
| Day of examination, . . . . .       | 23           | 22    | 22         | 20        |
| Number of sample, . . . . .         | 10157        | 10547 | 11073      | 11515     |
| <b>PLANTS.</b>                      |              |       |            |           |
| Diatomaceæ, . . . . .               | 291          | 39    | 33         | 1,829     |
| Asterionella, . . . . .             | 0            | 0     | 0          | 8         |
| Diatoma, . . . . .                  | 0            | 6     | 0          | 0         |
| Fragilaria, . . . . .               | 0            | 13    | 0          | 0         |
| Melosira, . . . . .                 | 11           | 4     | 33         | 21        |
| Navicula, . . . . .                 | pr.          | 6     | 0          | 0         |
| Pinnularia, . . . . .               | 0            | 3     | 0          | 0         |
| Synedra, . . . . .                  | 275          | 6     | 0          | 1,600     |
| Tabellaria, . . . . .               | 4            | 1     | 0          | 0         |
| Cyanophyceæ, Microcystis, . . . . . | 0            | 0     | 44         | 0         |
| Algae, . . . . .                    | 82           | 0     | 35         | 0         |
| Closterium, . . . . .               | 6            | 0     | 0          | 0         |
| Nephrocytium, . . . . .             | 0            | 0     | 3          | 0         |
| Protococcus, . . . . .              | 20           | 0     | 20         | 0         |
| Raphidium, . . . . .                | 0            | 0     | 12         | 0         |
| Tetraspora, . . . . .               | 2            | 0     | 0          | 0         |
| Zoospores, . . . . .                | 54           | 0     | 0          | 0         |
| Fungi, Crenothrix, . . . . .        | 1            | 1     | 0          | 0         |



**HINGHAM.***Microscopical Examination of Water from Fulling Mill Pond, Hingham*  
— Concluded.

[Number of organisms per cubic centimeter.]

|                                          | 1893.  |       |            |           |
|------------------------------------------|--------|-------|------------|-----------|
|                                          | March. | June. | September. | December. |
| <b>ANIMALS.</b>                          |        |       |            |           |
| <b>Rhizopoda,</b> . . . . .              | 0      | 0     | 1          | 4         |
| Dactylocepharium, . . . . .              | 0      | 0     | 0          | 4         |
| Diffugia, . . . . .                      | 0      | 0     | 1          | 0         |
| <b>Infusoria,</b> . . . . .              | 233    | 0     | 10         | 8         |
| Cryptomonas, . . . . .                   | 1      | 0     | 0          | 0         |
| Dinobryon, . . . . .                     | 64     | 0     | 0          | 0         |
| Dinobryon cases, . . . . .               | 4      | 0     | 0          | 1         |
| Gonium, . . . . .                        | 4      | 0     | 0          | 0         |
| Monas, . . . . .                         | 1      | 0     | 1          | 0         |
| Peridinium, . . . . .                    | 158    | 0     | 0          | 7         |
| Synura, . . . . .                        | 1      | 0     | 0          | 0         |
| Trachelomonas, . . . . .                 | 0      | 0     | 2          | 0         |
| <b>Vermes,</b> . . . . .                 | 0      | 0     | 0          | 2         |
| Anurea, . . . . .                        | 0      | 0     | 0          | 1         |
| Polyarthra, . . . . .                    | 0      | 0     | 0          | 1         |
| <b>Crustacea, Cyclops,</b> . . . . .     | .02    | 0     | 0          | 0         |
| <b>Miscellaneous, Zoöglæa,</b> . . . . . | 68     | 14    | 60         | 7         |
| <b>TOTAL,</b> . . . . .                  | 673    | 54    | 183        | 1,650     |

**WATER SUPPLY OF HINSDALE FIRE DISTRICT, HINSDALE.***Chemical Examination of Water from the Storage Reservoir of the Hinsdale Fire District.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |           | Chlorine. | NITROGEN AS |            | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|-----------|-----------|-------------|------------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            | Nitrates. |           | Nitrites.   |            |                  |           |
|         |                     |             |                |        |                         |                   |          | Total.      | Dissolved. |           |           |             | Suspended. |                  |           |
| 10303   | 1893.<br>May 15     | V. slight.  | Slight.        | 0.10   | 1.85                    | 0.70              | .0000    | .0138       | .0082      | .0056     | .03       | .0000       | .0000      | .2555            | 0.2       |
| 10797   | Aug. 14             | Distinct.   | Cons., yellow. | 0.30   | 2.55                    | 1.45              | .0000    | .0242       | .0154      | .0088     | .04       | .0000       | .0000      | .5095            | 0.2       |
| 11361   | Nov. 21             | Slight.     | Cons.          | 0.20   | 3.20                    | 2.00              | .0006    | .0274       | .0168      | .0106     | .06       | .0030       | .0000      | .6048            | 0.6       |
| Av.     | .....               | .....       | .....          | 0.20   | 2.53                    | 1.38              | .0002    | .0218       | .0135      | .0083     | .04       | .0010       | .0000      | .4566            | 0.3       |

Iron, .0075. Odor of the first two samples, vegetable; of the last, very disagreeable. — The samples were collected from the reservoir.

## FAIRHAVEN.

## WATER SUPPLY OF FAIRHAVEN. — FAIRHAVEN WATER COMPANY.

*Chemical Examination of Water from the Tubular Wells of the Fairhaven Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | 1895.               |             |            |        |                         |          |             |           |             |           |                  |           |       |
| 13893   | Jan. 17             | None.       | None.      | .00    | 5.50                    | .0002    | .0020       | 1.05      | .1000       | .0001     | .0158            | 1.9       | .0050 |
| 13878   | Feb. 23             | None.       | None.      | .02    | 4.80                    | .0000    | .0016       | 1.00      | .0730       | .0000     | .0829            | 1.7       | .0000 |
| 14200   | Apr. 22             | V. slight.  | None.      | .02    | 5.10                    | .0000    | .0008       | 1.01      | .0900       | .0002     | .0829            | 1.8       | .0080 |
| 14527   | June 21             | None.       | None.      | .15    | 6.15                    | .0000    | .0038       | 1.02      | .0480       | .0000     | .1732            | 1.4       | -     |
| 14939   | Aug. 30             | None.       | V. slight  | .25    | 5.40                    | .0002    | .0056       | 1.05      | .0330       | .0002     | .3850            | 1.6       | .0200 |
| 15453   | Oct. 31             | None.       | V. slight. | .38    | 6.20                    | .0000    | .0090       | 1.04      | .0320       | .0000     | .4953            | 1.8       | -     |
| 15781   | Dec. 20             | None.       | None.      | .12    | 5.50                    | .0006    | .0068       | 0.98      | .0350       | .0000     | .1848            | 1.8       | .0050 |
| Av.     | .....               | .....       | .....      | .13    | 5.52                    | .0001    | .0042       | 1.02      | .0587       | .0001     | .2028            | 1.7       | .0076 |

Odor, none. On heating, Nos. 14527 and 15453 had a faintly vegetable odor. — The samples were collected from a faucet at the pumping station.

*Microscopical Examination.*

No. 13878. Fungi, *Oreothrix*, 1. Miscellaneous, *Zoëglæa*, 10. Total, 11.

No. 13443. Fungi, *Oreothrix*, 5; *Molds*, 14. Miscellaneous, *Zoëglæa*, 2. Total, 21.

In the other samples no organisms were found.

## WATER SUPPLY OF FALL RIVER.

*Chemical Examination of Water from North Watuppa Lake.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13879   | 1895.<br>Feb. 25    | Slight.     | Slight.   | .40    | 3.30                    | 0.05              | .0012    | .0186       | .0162      | .0024      | .62       | .0030       | .0001     | .4700            | 0.8       |
| 14202   | Apr. 23             | Slight.     | Slight.   | .23    | 3.20                    | 1.10              | .0012    | .0230       | .0188      | .0042      | .58       | .0000       | .0000     | .4621            | 0.8       |
| 14346   | May 22              | Slight.     | Slight.   | .25    | 3.70                    | 1.45              | .0000    | .0158       | .0132      | .0026      | .57       | .0000       | .0000     | .4294            | 0.5       |
| Av.     | .....               | .....       | .....     | .29    | 3.40                    | 1.17              | .0008    | .0191       | .0161      | .0030      | .59       | .0010       | .0000     | .4538            | 0.7       |

Odor, vegetable. — The first sample was collected from a faucet in the city, the second from a faucet at the pumping station, and the last from the gate-house at the lake.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 13879, 600; No. 14202, 229; No. 14346, 228.

## HOLYOKE.

## WATER SUPPLY OF HOLYOKE.

The advice of the State Board of Health to the city of Holyoke, with regard to an additional water supply, may be found on page 19 of this volume. On pages 168 and 169 will be found analyses of samples of water collected from various sources examined in connection with the investigation for this supply.

*Chemical Examination of Water from Whiting Street Storage Reservoir,  
Holyoke.*

[Parts per 100,000.]

| Number.  | Date of Collection. | APPEARANCE.        |                   | Color. | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |                                |          | Chlorine. | NITROGEN<br>AS |       | Oxygen Consumed. | Hardness. |
|----------|---------------------|--------------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|--------------------------------|----------|-----------|----------------|-------|------------------|-----------|
|          |                     | Turbidity.         | Sediment.         |        | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |                                | Nitrate. |           | Nitrite.       |       |                  |           |
|          |                     |                    |                   |        |                                 |                      |          | Total.      | Dissolved<br>Un-<br>suspended. |          |           |                |       |                  |           |
| 1893.    |                     |                    |                   |        |                                 |                      |          |             |                                |          |           |                |       |                  |           |
| 9903     | Jan. 13             | Distinct.          | Slight.           | 0.50   | 5.65                            | 1.70                 | .0024    | .0340       | .0236                          | .0104    | .18       | .0100          | .0001 | .4767            | 3.0       |
| 10146    | Mar. 21             | Slight.            | Slight.           | 0.08   | 3.25                            | 1.25                 | .0000    | .0154       | .0114                          | .0040    | .13       | .0000          | .0000 | .2160            | 1.4       |
| 10442    | May 22              | Slight.            | Slight.           | 0.20   | 3.95                            | 1.20                 | .0016    | .0158       | .0140                          | .0018    | .11       | .0000          | .0000 | .3562            | 2.1       |
| 10632    | July 10             | Slight.            | Slight,<br>green. | 0.12   | 5.20                            | 2.45                 | .0000    | .0212       | .0182                          | .0030    | .10       | .0030          | .0001 | .3577            | 2.7       |
| 11049    | Sept. 19            | Decided,<br>green. | Cons.             | 0.18   | 5.55                            | 1.70                 | .0000    | .0426       | .0244                          | .0182    | .15       | .0030          | .0000 | .4425            | 3.1       |
| 11363    | Nov. 21             | V. slight.         | Slight.           | 0.20   | 4.40                            | 1.45                 | .0008    | .0216       | .0180                          | .0036    | .12       | .0220          | .0002 | .4536            | 2.5       |
| Av. .... |                     |                    |                   | 0.18   | 4.67                            | 1.63                 | .0008    | .0251       | .0183                          | .0068    | .13       | .0063          | .0001 | .3838            | 2.5       |

*Averages of Analyses of Previous Years.*

*From Brook before Reservoir was Built.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |   |   |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|---|---|
| - | 1887* | - | - | 0.48 | 7.59 | 1.44 | .0024 | .0204 | -     | -     | .13 | .0126 | -     | - | - |
| - | 1888  | - | - | 0.25 | 6.63 | 1.22 | .0009 | .0183 | -     | -     | .10 | .0081 | .0001 | - | - |
| - | 1889* | - | - | 0.14 | 6.72 | 1.02 | .0006 | .0134 | .0092 | .0042 | .11 | .0054 | .0001 | - | - |

*From Reservoir.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1890; | - | - | 0.50 | 6.95 | 1.60 | .0008 | .0244 | .0188 | .0036 | .15 | .0120 | .0000 | -     | 3.6 |
| - | 1891  | - | - | 0.41 | 6.24 | 2.05 | .0125 | .0311 | .0258 | .0058 | .12 | .0185 | .0006 | -     | 3.1 |
| - | 1892  | - | - | 0.30 | 5.57 | 1.86 | .0020 | .0294 | .0247 | .0047 | .14 | .0192 | .0001 | -     | 2.5 |
| - | 1893  | - | - | 0.18 | 4.67 | 1.63 | .0008 | .0251 | .0183 | .0068 | .13 | .0063 | .0001 | .3838 | 2.5 |

\* June to December.

; January to May.

1 December.

NOTE to analyses of 1893: Iron, .0101. Odor of the first three samples, distinctly vegetable, and of the first, also disagreeable; of the last three samples, faintly vegetable or none. On heating, the odor of all samples was distinctly vegetable. — The samples were collected from the reservoir.

## HOLYOKE.

*Microscopical Examination of Water from Whiting Street Storage Reservoir,  
Holyoke.*

[Number of organisms per cubic centimeter.]

|                                 | 1893.      |              |              |           |              |           |
|---------------------------------|------------|--------------|--------------|-----------|--------------|-----------|
|                                 | Jan.       | March.       | May.         | July.     | Sept.        | Nov.      |
| Day of examination, . . . . .   | 20         | 23           | 24           | 13        | 20           | 22        |
| Number of sample, . . . . .     | 9903       | 10146        | 10442        | 10632     | 11049        | 11363     |
| <b>PLANTS.</b>                  |            |              |              |           |              |           |
| Diatomaceæ, . . . . .           | 1          | 1            | 3            | 0         | 782          | 4         |
| Asterionella, . . . . .         | 0          | 0            | 0            | 0         | 720          | 3         |
| Fragilaria, . . . . .           | 0          | 0            | 0            | 0         | 62           | 0         |
| Synedra, . . . . .              | 1          | 1            | 3            | 0         | 0            | 1         |
| Cyanophyceæ, Chroococcus, . .   | 0          | 0            | 24           | 0         | 0            | 0         |
| Algæ, . . . . .                 | 0          | 1,464        | 1,422        | 0         | 196          | 2         |
| Pandorina, . . . . .            | 0          | 0            | 42           | 0         | 0            | 0         |
| Pediastrum, . . . . .           | 0          | 0            | 0            | 0         | 4            | 0         |
| Protococcus, . . . . .          | 0          | 0            | 0            | 0         | 192          | 2         |
| Selenastrum, . . . . .          | 0          | 0            | 1,380        | 0         | 0            | 0         |
| Zoospores, . . . . .            | 0          | 1,464        | 0            | 0         | 0            | 0         |
| Fungi, Crenothrix, . . . . .    | 0          | 0            | 3            | 1         | 0            | 0         |
| <b>ANIMALS.</b>                 |            |              |              |           |              |           |
| Infusoria, . . . . .            | 168        | 3            | 0            | 1         | 62           | 4         |
| Cryptomonas, . . . . .          | 164        | 0            | 0            | 0         | 0            | 0         |
| Dinobryon, . . . . .            | 0          | 3            | 0            | 0         | 0            | 0         |
| Euglena, . . . . .              | 0          | 0            | 0            | 0         | 5            | 0         |
| Monas, . . . . .                | 0          | 0            | 0            | 1         | 0            | 0         |
| Peridinium, . . . . .           | 1          | pr.          | 0            | 0         | 5            | 4         |
| Trachelomonas, . . . . .        | 0          | 0            | 0            | 0         | 52           | 0         |
| Uroglena, . . . . .             | 3          | 0            | 0            | 0         | 0            | 0         |
| Vermes, Polyanthra, . . . . .   | 0          | 0            | 0            | 0         | 1            | 0         |
| Miscellaneous, Zoöglæa, . . . . | 0          | 52           | 3            | 56        | 3            | 0         |
| <b>TOTAL, . . . . .</b>         | <b>169</b> | <b>1,520</b> | <b>1,455</b> | <b>58</b> | <b>1,044</b> | <b>10</b> |

## FITCHBURG.

*Chemical Examination of Water from Meeting-house Pond, Westminster.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 13676   | 1895.<br>Jan. 15    | V. slight.  | V. slight. | .10    | 2.50                            | 0.85                 | .0018    | .0150       | .0140      | .0010           | .24       | .0060          | .0000     | .2251            | 0.8       |
| 14026   | Mar. 20             | V. slight.  | Cons.      | .05    | 2.40                            | 0.85                 | .0026    | .0140       | .0126      | .0014           | .20       | .0030          | .0000     | .2172            | 0.9       |
| 14315   | May 16              | Slight.     | Slight.    | .10    | 2.60                            | 0.95                 | .0012    | .0140       | .0120      | .0020           | .14       | .0000          | .0000     | .2291            | 0.9       |
| 14668   | July 22             | Slight.     | Slight.    | .10    | 2.50                            | 0.80                 | .0000    | .0144       | .0130      | .0014           | .18       | .0000          | .0000     | .2250            | 0.6       |
| 15193   | Sept. 16            | Slight.     | Slight.    | .08    | 2.30                            | 0.80                 | .0000    | .0172       | .0154      | .0018           | .19       | .0000          | .0000     | .2301            | 0.6       |
| 15577   | Nov. 19             | None.       | V. slight. | .15    | 3.35                            | 1.30                 | .0014    | .0118       | .0108      | .0010           | .24       | .0070          | .0000     | .8346            | 1.1       |
| Av.     | .....               | .....       | .....      | .10    | 2.61                            | 0.92                 | .0012    | .0144       | .0130      | .0014           | .20       | .0027          | .0000     | .3268            | 0.8       |

*Averages by Years.*

|   |      |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1893 | - | - | .07 | 2.37 | 0.88 | .0009 | .0137 | .0113 | .0024 | .17 | .0023 | .0000 | .2204 | 0.6 |
| - | 1894 | - | - | .07 | 2.38 | 0.86 | .0011 | .0149 | .0125 | .0024 | .18 | .0026 | .0000 | .2162 | 0.6 |
| - | 1895 | - | - | .10 | 2.61 | 0.92 | .0012 | .0144 | .0130 | .0014 | .20 | .0027 | .0000 | .3268 | 0.8 |

NOTE to analyses of 1895: Odor, generally faintly vegetable. — The samples were collected from the pond as follows: The first sample near the shore north of the overflow; the second, just below dam; the remaining samples from the gate-house.

*Microscopical Examination of Water from Meeting-house Pond, Westminster.*

[Number of organisms per cubic centimeter.]

|                               | 1895. |       |       |       |       |       |
|-------------------------------|-------|-------|-------|-------|-------|-------|
|                               | Jan.  | Mar.  | May.  | July  | Sept. | Nov.  |
| Day of examination, . . . . . | 17    | 21    | 17    | 24    | 19    | 30    |
| Number of sample, . . . . .   | 13676 | 14026 | 14315 | 14668 | 15193 | 15577 |
| PLANTS.                       |       |       |       |       |       |       |
| Diatomaceæ, . . . . .         | 2     | 10    | 59    | 52    | 12    | 0     |
| Cyclotella, . . . . .         | 0     | 0     | 0     | 14    | 1     | 0     |
| Fragillaria, . . . . .        | 0     | 0     | 0     | 13    | 0     | 0     |
| Synedra, . . . . .            | 2     | 7     | 40    | 19    | 7     | 0     |
| Tabellaria, . . . . .         | 0     | 3     | 19    | 6     | 4     | 0     |

## HOLYOKE.

*Microscopical Examination of Water from Wright and Ashley Ponds, Holyoke.*

[Number of organisms per cubic centimeter

|                                   | 1893. |        |       |       |       |       |
|-----------------------------------|-------|--------|-------|-------|-------|-------|
|                                   | Jan.  | March. | May.  | July. | Sept. | Nov.  |
| Day of examination, . . . . .     | 20    | 23     | 24    | 13    | 20    | 22    |
| Number of sample, . . . . .       | 9904  | 10145  | 10441 | 10631 | 11048 | 11362 |
| PLANTS.                           |       |        |       |       |       |       |
| Diatomaceæ, . . . . .             | 394   | 10     | 85    | 0     | 40    | 1,067 |
| Asterionella, . . . . .           | 2     | 0      | 0     | 0     | 0     | 36    |
| Cyclotella, . . . . .             | 4     | 0      | 22    | 0     | 1     | 0     |
| Diatoma, . . . . .                | 264   | 0      | 0     | 0     | 0     | 0     |
| Fragilaria, . . . . .             | 6     | 2      | 16    | 0     | 15    | 70    |
| Melosira, . . . . .               | 14    | 1      | 19    | 0     | 14    | 720   |
| Stephanodiscus, . . . . .         | 0     | 0      | 0     | 0     | 0     | 9     |
| Synedra, . . . . .                | 92    | 6      | 20    | 0     | 4     | 100   |
| Tabellaria, . . . . .             | 12    | 1      | 8     | 0     | 6     | 132   |
| Cyanophyceæ, . . . . .            | 6     | 0      | 0     | 0     | 26    | 2     |
| Anabaena, . . . . .               | pr.   | 0      | 0     | 0     | 24    | 0     |
| Chroococcus, . . . . .            | 6     | 0      | 0     | 0     | 0     | 0     |
| Microcystis, . . . . .            | pr.   | 0      | 0     | 0     | 2     | 2     |
| Algæ, . . . . .                   | 18    | 0      | 0     | 0     | 13    | 47    |
| Chlorococcus, . . . . .           | pr.   | 0      | 0     | 0     | 3     | 0     |
| Closterium, . . . . .             | 2     | 0      | 0     | 0     | 1     | 0     |
| Dictyosphaerium, . . . . .        | 12    | 0      | 0     | 0     | 0     | 0     |
| Protococcus, . . . . .            | 4     | 0      | 0     | 0     | 4     | 33    |
| Raphidium, . . . . .              | 0     | 0      | 0     | 0     | 5     | 14    |
| ANIMALS.                          |       |        |       |       |       |       |
| Rhizopoda, . . . . .              | 15    | 0      | 0     | 0     | 0     | 3     |
| Actinophrys, . . . . .            | 15    | 0      | 0     | 0     | 0     | 2     |
| Diffugia, . . . . .               | pr.   | 0      | 0     | 0     | 0     | 1     |
| Infusoria, . . . . .              | 11    | 2      | 0     | 26    | 24    | 267   |
| Dinobryon, . . . . .              | 6     | 0      | 0     | 0     | 0     | 6     |
| Dinobryon cases, . . . . .        | pr.   | 2      | 0     | 0     | 24    | 236   |
| Monas, . . . . .                  | 0     | 0      | 0     | 26    | 0     | 0     |
| Peridinium, . . . . .             | 3     | pr.    | 0     | 0     | 0     | 0     |
| Synura, . . . . .                 | pr.   | pr.    | 0     | 0     | 0     | 0     |
| Trachelomonas, . . . . .          | 2     | 0      | 0     | 0     | 0     | 5     |
| Vermes, . . . . .                 | 1     | 1      | 0     | 0     | 0     | 2     |
| Anurea, . . . . .                 | 1     | pr.    | 0     | 0     | 0     | 0     |
| Monocerca, . . . . .              | 0     | 0      | 0     | 0     | 0     | 1     |
| Rotarian ova, . . . . .           | 0     | 0      | 0     | 0     | 0     | 1     |
| Sacculus, . . . . .               | 0     | 1      | 0     | 0     | 0     | 0     |
| Miscellaneous, Zoöglæa, . . . . . | 92    | 110    | 0     | 100   | 16    | 2     |
| TOTAL, . . . . .                  | 537   | 123    | 85    | 126   | 119   | 1,390 |

**FRAMINGHAM.****WATER SUPPLY OF FRAMINGHAM. — FRAMINGHAM WATER COMPANY.***Chemical Examination of Water from the Filter-gallery of the Framingham Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albominal. |           | Nitrates.   | Nitrites. |                  |           |       |
| 13872   | Feb. 20             | None.       | None.     | .03    | 7.40                    | .0042    | .0044      | .88       | .0320       | .0000     | .0608            | 3.1       | .0270 |
| 14347   | May 22              | V. slight.  | Cons.     | .02    | 7.20                    | .0000    | .0072      | .98       | .0070       | .0000     | .0874            | 3.0       | .0020 |
| 14860   | Aug. 19             | Slight.     | Slight.   | .08    | 7.40                    | .0026    | .0038      | .91       | .0330       | .0001     | .0702            | 2.7       | .0250 |
| 15614   | Nov. 26             | None.       | None.     | .04    | 7.30                    | .0014    | .0044      | .92       | .0200       | .0001     | .0468            | 3.2       | .0040 |
| Av.     | .....               | .....       | .....     | .04    | 7.32                    | .0020    | .0049      | .92       | .0230       | .0000     | .0663            | 3.0       | .0130 |

*Averages by Years.*

|   |       |   |   |     |      |       |       |     |       |       |       |     |       |
|---|-------|---|---|-----|------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1887* | - | - | .08 | 5.82 | .0031 | .0124 | .43 | .0123 | -     | -     | -   | -     |
| - | 1888  | - | - | .10 | 5.81 | .0027 | .0081 | .44 | .0308 | .0004 | -     | -   | -     |
| - | 1889  | - | - | .00 | 6.18 | .0031 | .0050 | .56 | .0366 | .0002 | -     | -   | -     |
| - | 1890  | - | - | .00 | 7.09 | .0020 | .0039 | .65 | .0631 | .0001 | -     | 3.0 | -     |
| - | 1891  | - | - | .00 | 6.25 | .0023 | .0035 | .63 | .0707 | .0001 | -     | 2.8 | -     |
| - | 1892† | - | - | .13 | 5.43 | .0051 | .0081 | .59 | .0225 | .0018 | -     | 2.6 | -     |
| - | 1893  | - | - | .04 | 6.07 | .0026 | .0033 | .62 | .0460 | .0001 | .1104 | 2.6 | .0099 |
| - | 1894  | - | - | .03 | 6.75 | .0025 | .0043 | .79 | .0515 | .0001 | .0796 | 2.8 | .0272 |
| - | 1895  | - | - | .04 | 7.32 | .0020 | .0049 | .92 | .0230 | .0000 | .0663 | 3.0 | .0130 |

\* June to November.

† Two samples in October.

NOTE to analyses of 1895: Odor of the second sample, unpleasant; of the others, none. — The samples were collected from the filter-gallery.

*Chemical Examination of Water from a Faucet in South Framingham, supplied from the Works of the Framingham Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                |        | Residue on Evaporation. | AMMONIA. |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|----------------|--------|-------------------------|----------|------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment.      | Color. |                         | Free.    | Albominal. |           | Nitrates.   | Nitrites. |                  |           |       |
| 13873   | Feb. 20             | Slight.          | Slight.        | .03    | 7.20                    | .0000    | .0054      | .87       | .0150       | .0000     | .0640            | 3.1       | .0300 |
| 14348   | May 22              | Slight, milky.   | None.          | .18    | 7.90                    | .0012    | .0022      | .94       | .0000       | .0000     | .0479            | 2.9       | .0700 |
| 14861   | Aug. 19             | Distinct, rusty. | Slight, rusty. | .50    | 6.60                    | .0002    | .0024      | .91       | .0020       | .0001     | .0780            | 2.9       | .1400 |
| 15615   | Nov. 26             | Distinct, milky. | V. slight.     | .28    | 6.10                    | .0000    | .0034      | .90       | .0030       | .0001     | .0507            | 3.0       | .0370 |
| Av.     | .....               | .....            | .....          | .25    | 6.95                    | .0003    | .0033      | .90       | .0050       | .0000     | .0601            | 3.0       | .0602 |

Odor of the first sample, none, becoming very faintly vegetable on heating; of the second, distinctly unpleasant, disappearing on heating; of the third, decidedly tarry; of the last, none, becoming faintly tarry on heating.

## HOLYOKE.

*Microscopical Examination of Water from Various Sources, collected during an Investigation for an Additional Water Supply for Holyoke—Concluded.*

[Number of organisms per cubic centimeter.]

|                                          | 1893. |      |      |      |       |      |
|------------------------------------------|-------|------|------|------|-------|------|
|                                          | Aug.  | Aug. | Aug. | Aug. | Aug.  | Nov. |
| <b>PLANTS—Con.</b>                       |       |      |      |      |       |      |
| <b>Cyanophyceæ, . . . . .</b>            | 0     | 1    | 0    | 1    | 2,083 | 0    |
| Anabaena, . . . . .                      | 0     | 0    | 0    | 0    | 2,080 | 0    |
| Chroococcus, . . . . .                   | 0     | 0    | 0    | 1    | 0     | 0    |
| Clathrocystis, . . . . .                 | 0     | 0    | 0    | 0    | 3     | 0    |
| Oscillaria, . . . . .                    | 0     | 1    | 0    | 0    | 0     | 0    |
| <b>Algae, . . . . .</b>                  | 0     | 13   | 0    | 0    | 23    | 0    |
| Closterium, . . . . .                    | 0     | 0    | 0    | 0    | 2     | 0    |
| Conferva, . . . . .                      | 0     | 0    | 0    | 0    | 3     | 0    |
| Coenarium, . . . . .                     | 0     | 0    | 0    | 0    | 1     | 0    |
| Pediastrum, . . . . .                    | 0     | 1    | 0    | 0    | 0     | 0    |
| Raphidium, . . . . .                     | 0     | 6    | 0    | 0    | 10    | 0    |
| Sphaerozoema, . . . . .                  | 0     | 6    | 0    | 0    | 0     | 0    |
| Staurostrum, . . . . .                   | 0     | 0    | 0    | 0    | 5     | 0    |
| Zoosporea, . . . . .                     | 0     | 0    | 0    | 0    | 2     | 0    |
| <b>Fungi, . . . . .</b>                  | 0     | 116  | 13   | 13   | 0     | 81   |
| Beggiatoa, . . . . .                     | 0     | 0    | 1    | 0    | 0     | 0    |
| Crenothrix, . . . . .                    | 0     | 116  | 12   | 13   | 0     | 80   |
| Molds, . . . . .                         | 0     | 0    | 0    | 0    | 0     | 1    |
| <b>ANIMALS.</b>                          |       |      |      |      |       |      |
| <b>Infusoria, . . . . .</b>              | 0     | 352  | 0    | 0    | 57    | 1    |
| Dinobryon, . . . . .                     | 0     | 12   | 0    | 0    | 0     | 0    |
| Peridinium, . . . . .                    | 0     | 340  | 0    | 0    | 56    | 1    |
| Trachelomonas, . . . . .                 | 0     | 0    | 0    | 0    | 1     | 0    |
| <b>Vermes, . . . . .</b>                 | 0     | 0    | 0    | 0    | 3     | 0    |
| Anurea, . . . . .                        | 0     | 0    | 0    | 0    | 2     | 0    |
| Polyarthra, . . . . .                    | 0     | 0    | 0    | 0    | 1     | 0    |
| <b>Miscellaneous, Zoöglæa, . . . . .</b> | 2     | 40   | 54   | 4    | 32    | 60   |
| <b>TOTAL, . . . . .</b>                  | 3     | 547  | 72   | 22   | 2,282 | 143  |

## WATER SUPPLY OF HUDSON.

In the early part of 1893, particularly in January and the first part of February, this supply was affected by the presence of the organism *Uroglena*, the most noticeable characteristic of which is the oily odor which it imparts to water even when present in comparatively small numbers. This organism was present in the water supplies of Norwood and Plymouth in the years 1892 and 1893, and it has been found in other water supplies in the State. A description of this organism and an account of its effect upon the taste and odor



## HUDSON.

of water may be found in the twenty-third annual report of the State Board of Health, for 1891, pages 645-658.

*Chemical Examination of Water from Gates Pond, Berlin.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.    |                 |        | RESIDUE ON EVAPORATION. |                  | AMMONIA. |             |            |            |           | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|----------------|-----------------|--------|-------------------------|------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.     | Sediment.       | Color. | Total.                  | Loss on Ignition | Free.    | Albuminoid. |            |            | Chlorine. | Nitrates.   | Nitrites. |                  |           |
|         |                     |                |                 |        |                         |                  |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1893.   |                     |                |                 |        |                         |                  |          |             |            |            |           |             |           |                  |           |
| 9853    | Jan. 9              | V. slight.     | V. slight.      | 0.05   | 3.00                    | 1.25             | .0112    | .0278       | .0234      | .0044      | .25       | .0030       | .0001     | -                | 1.1       |
| 9875    | Jan. 13             | Slight.        | Slight.         | 0.05   | -                       | -                | -        | -           | -          | -          | -         | -           | -         | -                | -         |
| 9916    | Jan. 23             | V. slight.     | Slight, earthy. | 0.02   | 2.60                    | 1.20             | .0076    | .0310       | .0268      | .0042      | .20       | .0000       | .0000     | .2044            | 0.3       |
| 9980    | Feb. 8              | Slight.        | Slight.         | 0.05   | 2.55                    | 0.75             | .0156    | .0232       | .0222      | .0010      | .28       | .0080       | .0000     | .2372            | 0.3       |
| 10169   | Mar. 27             | Slight.        | Slight, earthy. | 0.04   | 2.20                    | 0.95             | .0063    | .0176       | .0120      | .0056      | .16       | .0250       | .0001     | .1971            | 0.3       |
| 10227   | Apr. 11             | Slight.        | Slight.         | 0.05   | 2.30                    | 0.75             | .0080    | .0140       | .0116      | .0024      | .27       | .0000       | .0000     | .1788            | 0.3       |
| 10359   | May 8               | Slight.        | Slight.         | 0.03   | 2.30                    | 0.80             | .0044    | .0098       | .0086      | .0012      | .20       | .0050       | .0000     | .1204            | 0.3       |
| 10422   | May 22              | Distinct.      | Cons.           | 0.05   | 2.15                    | 1.05             | .0006    | .0150       | .0124      | .0026      | .21       | .0000       | .0000     | .1650            | 0.3       |
| 10503   | June 12             | Slight, green. | Slight.         | 0.05   | 2.45                    | 1.00             | .0004    | .0144       | .0128      | .0016      | .26       | .0000       | .0000     | .1842            | 0.3       |
| 10560   | June 26             | Distinct.      | Slight.         | 0.03   | 2.40                    | 0.60             | .0000    | .0144       | .0122      | .0022      | .22       | .0030       | .0000     | .1501            | 0.3       |
| 10657   | July 13             | V. slight.     | V. slight.      | 0.04   | 2.50                    | 1.10             | .0000    | .0120       | .0096      | .0024      | .20       | .0050       | .0000     | .1971            | 0.3       |
| 10818   | Aug. 16             | Distinct.      | Slight.         | 0.10   | 2.35                    | 0.65             | .0000    | .0154       | .0106      | .0048      | .22       | .0000       | .0000     | .1619            | 0.4       |
| 11044   | Sept. 19            | Distinct.      | Slight.         | 0.03   | 2.70                    | 1.20             | .0010    | .0274       | .0218      | .0056      | .26       | .0000       | .0000     | .2132            | 0.6       |
| 11178   | Oct. 12             | Slight.        | Slight.         | 0.05   | 2.00                    | 1.00             | .0000    | .0140       | .0114      | .0026      | .25       | .0000       | .0000     | .2025            | 0.6       |
| 11327   | Nov. 13             | Slight.        | Slight.         | 0.05   | 2.25                    | 0.95             | .0010    | .0166       | .0132      | .0034      | .22       | .0020       | .0000     | .2448            | 0.8       |
| 11504   | Dec. 18             | V. slight.     | V. slight.      | 0.02   | 3.10                    | 1.85             | .0038    | .0170       | .0145      | .0022      | -         | .0000       | .0000     | .2106            | 0.9       |
| Av.*    | .....               | .....          | .....           | 0.05   | 2.46                    | 1.01             | .0040    | .0178       | .0146      | .0032      | .23       | .0039       | .0000     | .1965            | 0.6       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1897† | - | - | 0.06 | 3.17 | 0.71 | .0014 | .0150 | -     | -     | .21 | .0054 | -     | -     | -   |
| - | 1888  | - | - | 0.06 | 2.55 | 0.69 | .0015 | .0158 | -     | -     | .19 | .0053 | .0001 | -     | -   |
| - | 1889  | - | - | 0.03 | 2.14 | 0.58 | .0020 | .0189 | .0139 | .0050 | .19 | .0048 | .0001 | -     | -   |
| - | 1890  | - | - | 0.02 | 2.32 | 1.04 | .0023 | .0161 | .0124 | .0037 | .21 | .0054 | .0000 | -     | 1.2 |
| - | 1891  | - | - | 0.04 | 2.52 | 0.90 | .0011 | .0150 | .0117 | .0033 | .20 | .0074 | .0000 | -     | 0.9 |
| - | 1893  | - | - | 0.05 | 2.45 | 1.01 | .0040 | .0178 | .0146 | .0032 | .23 | .0039 | .0000 | .1965 | 0.6 |

\* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

† June to December.

Note to analyses of 1893: Iron, .0040. Odor, generally vegetable or none. A faintly oily odor was detected in Nos. 9875, 9916 and 10422. On heating, a decided oily odor was developed in the samples collected between January 13 and February 8 inclusive, and in the samples collected on May 22 and in June. — The samples were collected from the pond at the surface.

HUDSON.

*Microscopical Examination of Water from Gates Pond, Berlin.*

[Number of organisms per cubic centimeter.]

|                     | 1893. |      |      |      |       |       |       |       |       |       |       |       |       |       |       |
|---------------------|-------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                     | Jan.  | Jan. | Jan. | Feb. | Mar.  | Apr.  | May.  | May.  | June. | June. | July. | Aug.  | Sept. | Oct.  | Nov.  |
| Day of examination, | 10    | 14   | 24   | 9    | 29    | 12    | 9     | 23    | 13    | 27    | 15    | 17    | 20    | 13    | 14    |
| Number of sample,   | 9853  | 9875 | 9916 | 9980 | 10169 | 10227 | 10359 | 10422 | 10603 | 10560 | 10657 | 10818 | 11044 | 11178 | 11327 |
|                     |       |      |      |      |       |       |       |       |       |       |       |       |       |       |       |
| PLANTS.             |       |      |      |      |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, .       | 30    | 3    | 0    | 0    | 22    | 80    | 351   | 179   | 166   | 10    | 0     | 18    | 26    | 12    | 791   |
| Asterionella, .     | 0     | 0    | 0    | 0    | 4     | 5     | 71    | 120   | 1     | 0     | 0     | 3     | 1     | 0     | 400   |
| Fragilaria, .       | 0     | 0    | 0    | 0    | 0     | 0     | 0     | 3     | 6     | 0     | 0     | 0     | 3     | 0     | 0     |
| Melosira, .         | 2     | 0    | 0    | 0    | 2     | 60    | 240   | 7     | 8     | 0     | 0     | 0     | 3     | 8     | 372   |
| Synedra, .          | 28    | 3    | 0    | 0    | 13    | 15    | 6     | 2     | 1     | 1     | pr.   | 3     | 1     | 0     | 8     |
| Tabellaria, .       | 0     | 0    | 0    | 0    | 3     | 0     | 34    | 47    | 150   | 9     | pr.   | 12    | 18    | 4     | 11    |
| Cyanophyceæ, .      | 0     | 0    | 0    | 0    | 0     | 0     | 0     | 0     | 44    | 21    | 0     | 134   | 180   | 1     | 0     |
| Anabæna, .          | 0     | 0    | 0    | 0    | 0     | 0     | 0     | 0     | 31    | 3     | 0     | 50    | 0     | 1     | 0     |
| Celosphaerium, .    | 0     | 0    | 0    | 0    | 0     | 0     | 0     | 0     | 13    | 0     | 0     | 0     | 180   | 0     | 0     |
| Microcystis, .      | 0     | 0    | 0    | 0    | 0     | 0     | 0     | 0     | 0     | 18    | 0     | 84    | 0     | 0     | 0     |
| Algæ, .             | 0     | pr.  | 0    | 0    | 1     | 4     | 13    | 11    | 118   | 133   | 3     | 1     | 15    | 3     | 36    |
| Chlorococcus, .     | 0     | 0    | 0    | 0    | 1     | 0     | 0     | 1     | 3     | 1     | 0     | 0     | 6     | 3     | 0     |
| Pandorina, .        | 0     | 0    | 0    | 0    | 0     | 0     | 0     | 4     | 5     | 0     | 0     | 0     | 0     | 0     | 0     |
| Protococcus, .      | 0     | 0    | 0    | 0    | 0     | 0     | 12    | 5     | 94    | 70    | 2     | 0     | 5     | 0     | 35    |
| Raphidium, .        | 0     | 0    | 0    | 0    | 0     | 0     | 0     | 0     | 10    | 58    | 0     | 0     | 3     | 0     | 0     |
| Staurostrum, .      | 0     | 0    | 0    | 0    | 0     | 0     | 1     | 1     | 6     | 2     | 1     | 1     | 1     | 0     | 1     |
| Zoospores, .        | 0     | pr.  | 0    | 0    | pr.   | 4     | 0     | 0     | 0     | 2     | pr.   | 0     | 0     | 0     | 0     |
| ANIMALS.            |       |      |      |      |       |       |       |       |       |       |       |       |       |       |       |
| Rhizopoda, .        | pr.   | pr.  | pr.  | 0    | pr.   | 1     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 1     | 2     |
| Actinophrys, .      | 0     | 0    | 0    | 0    | pr.   | 1     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 2     |
| Diffugia, .         | pr.   | pr.  | pr.  | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     |
| Infusoria, .        | 78    | 153  | 176  | 48   | 56    | 10    | 207   | 174   | 109   | 159   | 2     | 64    | 0     | 9     | 492   |
| Dinobryon, .        | 0     | 134  | 166  | 4    | 19    | 8     | 20    | 0     | 2     | 134   | 0     | 4     | 0     | 0     | 136   |
| Dinobryon cases, .  | 78    | 14   | 0    | 42   | 34    | 0     | 186   | 172   | 98    | 22    | 2     | 24    | 0     | 0     | 240   |
| Monas, .            | pr.   | 0    | 0    | 0    | 0     | 0     | 0     | 0     | pr.   | 0     | 0     | 0     | 0     | 0     | 2     |
| Peridinium, .       | 0     | 2    | 0    | 0    | 3     | 2     | 1     | 2     | 5     | 2     | pr.   | 36    | 0     | 8     | 2     |
| Trachelomonas, .    | 0     | pr.  | 0    | 0    | 0     | 0     | 0     | 0     | pr.   | 1     | 0     | 0     | 0     | 1     | 2     |
| Uroglena, .         | 0     | 3    | 10   | 2    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Vorticella, .       | 0     | 0    | 0    | 0    | 0     | 0     | 0     | 0     | 4     | 0     | 0     | 0     | 0     | 9     | 0     |
| Vermes, .           | 0     | pr.  | 0    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     |
| Polyarthra, .       | 0     | pr.  | 0    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     |
| Miscellaneous, .    | 0     | 0    | 0    | 0    | 80    | 12    | 22    | 20    | 42    | 8     | 26    | 60    | 3     | 32    | 36    |
| Acarina, .          | 0     | 0    | 0    | 0    | 0     | 0     | 0     | 0     | .02   | .01   | 0     | 0     | .01   | .06   | 0     |
| Zoöglæa, .          | 0     | 0    | 0    | 0    | 60    | 12    | 22    | 20    | .42   | 8     | 26    | 60    | 3     | 32    | 36    |
| TOTAL, .            | 108   | 156  | 176  | 48   | 139   | 107   | 693   | 386   | 479   | 331   | 31    | 277   | 224   | 58    | 1,348 |

**GLOUCESTER.****WATER SUPPLY OF GLOUCESTER.**

The works of the Gloucester Water Company were taken by the city Oct. 1, 1895.

The advice of the State Board of Health to the city of Gloucester, relative to its present and prospective sources of water supply, may be found on pages 20-23 of this volume. Analyses of samples of water collected during the investigation of the present supply and of the proposed sources of supply are given in the following tables.

*Chemical Examination of Water from Dike's Brook Storage Reservoir, Gloucester.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>as |           | Oxygen Consumed | Hardness. |
|---------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|-----------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                 |           |
|         |                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                 |           |
| 13763   | Feb. 4              | V.slight.   | Slight.   | .60    | 4.35                            | 1.35                 | .0062    | .0204       | .0182      | .0022           | 1.05      | .0070          | .0000     | .5688           | 0.3       |
| 14426   | June 4              | Distinct.   | Slight.   | .30    | 3.85                            | 1.30                 | .0024    | .0188       | .0150      | .0038           | 0.97      | .0050          | .0000     | .3443           | 0.2       |
| 14771   | Aug. 6              | Distinct.   | Slight.   | .50    | 4.35                            | 1.50                 | .0000    | .0216       | .0192      | .0024           | 0.97      | .0100          | .0000     | .6408           | 0.8       |
| 14998   | Sept. 3             | Slight.     | Slight.   | .30    | 4.40                            | 2.00                 | .0018    | .0202       | .0184      | .0018           | 0.92      | .0000          | .0002     | .4290           | 0.2       |
| 15491   | Nov. 6              | None.       | V.slight. | .60    | 4.25                            | 1.75                 | .0042    | .0200       | .0158      | .0042           | 0.90      | .0050          | .0000     | .4820           | 0.2       |
| Av.     | .....               | .....       | .....     | .46    | 4.24                            | 1.58                 | .0029    | .0202       | .0173      | .0029           | 0.96      | .0054          | .0000     | .4930           | 0.3       |

Odor, vegetable; in June and November, also mouldy. — The samples were collected from the reservoir.

*Microscopical Examination of Water from Dike's Brook Storage Reservoir, Gloucester.*

[Number of organisms per cubic centimeter.]

|                                      | 1895. |       |       |       |       |
|--------------------------------------|-------|-------|-------|-------|-------|
|                                      | Feb.  | July. | Aug.  | Sept. | Nov.  |
| Day of examination, . . . . .        | 6     | 7     | 8     | 7     | 8     |
| Number of sample, . . . . .          | 13763 | 14426 | 14771 | 14998 | 15491 |
| <b>PLANTS.</b>                       |       |       |       |       |       |
| Diatomaceæ, . . . . .                | 0     | 9     | 85    | 0     | 1     |
| Cyclotella, . . . . .                | 0     | 2     | 1     | 0     | 0     |
| Synedra, . . . . .                   | 0     | 7     | 84    | 0     | 1     |
| Cyanophyceæ, Merismopedia, . . . . . | 0     | 0     | 10    | 0     | 0     |

HUDSON.

*Microscopical Examination of Water from Faucets in Hudson, supplied from Gales Pond—Concluded.*

[Number of organisms per cubic centimeter.]

|                           | 1893. |      |      |      |      |      |      |      |      |      |      |       |
|---------------------------|-------|------|------|------|------|------|------|------|------|------|------|-------|
|                           | Jan.  | Jan. | Jan. | Jan. | Jan. | Jan. | Feb. | Mar. | Mar. | Mar. | Mar. | June. |
| PLANTS—Con.               |       |      |      |      |      |      |      |      |      |      |      |       |
| Algae, . . . . .          | 190   | 57   | 69   | 75   | 0    | 6    | 0    | 0    | 0    | 0    | 0    | 34    |
| Nephrocytium, . . . .     | 4     | 2    | 3    | 5    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 4     |
| Protoecoccus, . . . .     | 186   | 54   | 64   | 68   | 0    | 6    | 0    | 0    | 0    | 0    | 0    | 3     |
| Raphidium, . . . . .      | 0     | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 22    |
| Staurostrum, . . . . .    | 0     | 1    | 2    | 2    | 0    | pr.  | 0    | 0    | 0    | 0    | 0    | 5     |
| ANIMALS.                  |       |      |      |      |      |      |      |      |      |      |      |       |
| Infusoria, . . . . .      | 4     | 18   | 8    | 22   | 1    | 18   | 1    | 21   | 0    | 27   | 2    | 35    |
| Dinobryon, . . . . .      | 0     | 5    | 4    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0     |
| Dinobryon cases, . . .    | 4     | 13   | 4    | 21   | 0    | 18   | 1    | 21   | 0    | 26   | 2    | 32    |
| Peridinium, . . . . .     | 0     | pr.  | 0    | 1    | 1    | 0    | 0    | 0    | 0    | 1    | 0    | 3     |
| Trachelomonas, . . . .    | 0     | 0    | pr.  | 0    | 0    | pr.  | 0    | 0    | 0    | 0    | pr.  | 0     |
| Miscellaneous, Zoöglæa, . | 124   | 16   | 18   | 3    | 0    | 40   | 0    | 3    | 0    | 38   | 24   | 24    |
| TOTAL, . . . . .          | 555   | 449  | 591  | 522  | 4    | 238  | 11   | 25   | 0    | 70   | 29   | 195   |

*Table showing Heights of Water in Gales Pond once each Month during 1893.*

[High-water mark is 14 feet.]

| DATE.—1893.        | Feet. | DATE.—1893.         | Feet. |
|--------------------|-------|---------------------|-------|
| Jan. 15, . . . . . | 10.0  | July 15, . . . . .  | 12.75 |
| Feb. 15, . . . . . | 10.6  | Aug. 15, . . . . .  | 11.8  |
| Mar. 15, . . . . . | 11.4  | Sept. 15, . . . . . | 11.3  |
| Apr. 15, . . . . . | 12.4  | Oct. 15, . . . . .  | 10.9  |
| May 15, . . . . .  | 13.5  | Nov. 15, . . . . .  | 10.75 |
| June 15, . . . . . | 13.5  | Dec. 15, . . . . .  | 10.7  |

WATER SUPPLY OF HULL.

(See *Hingham*.)

WATER SUPPLY OF HYDE PARK AND MILTON.—HYDE PARK WATER COMPANY.

The works of this company for obtaining a supply of ground water in the vicinity of the Neponset River were enlarged early in 1893, by sinking thirty-three tubular wells, located between the old systems of tubular wells and the starch factory well mentioned in the annual

**HYDE PARK AND MILTON.**

report of the Board for 1892. The new wells are in parallel lines on either side of a suction pipe placed approximately at right angles to the river, their distances from the river varying from sixty-four to nearly two hundred feet. The new wells are two and a half inches in diameter and of various depths, ranging from about twenty to twenty-eight feet. Twelve of the wells nearest the river have been disconnected, but the remaining wells have been in use since they were connected with the pump in the summer.

The advice of the State Board of Health to the Hyde Park Water Company, with reference to the use of water from these wells, may be found on page 20 of this volume, and analyses of water from three are given on page 176. The temperatures of the water in the wells from which these samples were collected differed considerably one from another, and were as follows: of the well nearest the river (No. 5), forty-nine degrees; of the well near the middle of the group (No. 14), forty-one degrees; of the well farthest from the river (No. 36), forty-four degrees.

*Chemical Examination of Water from the Tubular Wells of the Hyde Park Water Company.*

[Parts per 100,000.]

| Number.  | Date of Collection. | APPEARANCE. |                |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|----------|---------------------|-------------|----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|          |                     | Turbidity.  | Sediment.      | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 9871     | 1893.<br>Jan. 11    | None.       | None.          | 0.00   | 9.15                    | .0056    | .0044       | 1.30      | .0120       | .0003     | .0592            | 4.3       | .0160 |
| 9989     | Feb. 8              | None.       | None.          | 0.02   | 9.50                    | .0056    | .0024       | 1.36      | .1000       | .0005     | .0606            | 4.9       | .0170 |
| 10090    | Mar. 7              | None.       | None.          | 0.03   | 8.90                    | .0022    | .0002       | 1.19      | .0750       | .0004     | .0504            | 4.4       | .0160 |
| 10224    | Apr. 10             | None.       | None.          | 0.02   | 7.50                    | .0014    | .0016       | 0.96      | .1100       | .0001     | .0766            | 3.0       | .0100 |
| 10373    | May 9               | None.       | None.          | 0.01   | 7.25                    | .0012    | .0012       | 0.91      | .1100       | .0001     | .0876            | 2.9       | .0050 |
| 10493    | June 7              | None.       | None.          | 0.00   | 7.45                    | .0024    | .0034       | 0.92      | .0900       | .0001     | .0839            | 3.0       | .0040 |
| 10643    | July 11             | None.       | Slight, rusty. | 0.04   | 8.50                    | .0030    | .0044       | 1.10      | .0900       | .0000     | .1095            | 8.5       | .0125 |
| 10758    | Aug. 9              | None.       | None.          | 0.02   | 9.20                    | .0054    | .0048       | 1.33      | .0900       | .0003     | .1232            | 3.9       | .0040 |
| 10958    | Sept. 7             | Distinct.   | Cons., rusty.  | 0.05   | 8.80                    | .0014    | .0056       | 1.36      | .0900       | .0001     | .1716            | 4.1       | .0350 |
| 11137    | Oct. 3              | None.       | None.          | 0.02   | 9.40                    | .0030    | .0044       | 1.26      | .0800       | .0001     | .1155            | 2.6       | .0015 |
| 11318    | Nov. 9              | None.       | V. slight.     | 0.03   | 9.20                    | .0034    | .0030       | 1.44      | .1200       | .0001     | .1360            | 4.0       | .0025 |
| Av. .... | .....               | .....       | .....          | 0.02   | 8.62                    | .0031    | .0032       | 1.19      | .0879       | .0002     | .0976            | 3.7       | .0112 |

## HYDE PARK AND MILTON.

*Chemical Examination of Water from the Tubular Wells of the Hyde Park Water Company — Concluded.*

*Averages of Analyses of Previous Years.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albu- minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| -       | 1887*               | -           | -         | 0.00   | 6.67                    | .0004    | .0012         | 0.82      | .0699       | -         | -                | -         | -     |
| -       | 1888                | -           | -         | 0.00   | 6.06                    | .0001    | .0023         | 0.75      | .0641       | .0002     | -                | -         | -     |
| -       | 1889†               | -           | -         | 0.00   | 5.76                    | .0001    | .0019         | 0.68      | .0596       | .0001     | -                | -         | -     |
| -       | 1890‡               | -           | -         | 0.02   | 9.35                    | .0006    | .0023         | 0.88      | .0550       | .0002     | -                | 4.2       | -     |
| -       | 1891§               | -           | -         | 0.03   | 9.10                    | .0000    | .0040         | 0.96      | .0675       | .0002     | -                | 3.6       | -     |
| -       | 1892                | -           | -         | 0.00   | 7.20                    | .0004    | .0035         | 0.99      | .0500       | .0004     | -                | 3.0       | -     |
| -       | 1893                | -           | -         | 0.02   | 8.62                    | .0031    | .0032         | 1.19      | .0879       | .0002     | .0976            | 3.7       | .0112 |

\* June to December.

† January to May.

‡ February and August.

§ June and September.

|| Two samples in July.

Note to analyses of 1893: Odor, none. — The samples were collected from a faucet at the pumping station.

*Microscopical Examination of Water from the Tubular Wells of the Hyde Park Water Company.*

[Number of organisms per cubic centimeter.]

|                              | 1893. |      |       |       |       |       |       |       |       |       |       |
|------------------------------|-------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                              | Jan.  | Feb. | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  |
| Day of examination, . . .    | 13    | 9    | 8     | 12    | 10    | 9     | 13    | 10    | 9     | 5     | 11    |
| Number of sample, . . .      | 9871  | 9989 | 10090 | 10224 | 10373 | 10493 | 10643 | 10758 | 10988 | 11137 | 11318 |
| PLANTS.                      |       |      |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, Synedra, . .     | 0     | 0    | 0     | 46    | 0     | pr.   | 0     | 0     | 0     | 0     | 0     |
| Fungi, . . . . .             | 0     | 0    | 3     | 0     | 0     | 0     | 15    | 3     | 372   | 0     | 4     |
| Crenothrix, . . . . .        | 0     | 0    | 3     | 0     | 0     | 0     | 13    | 2     | 300   | 0     | 4     |
| Molds, . . . . .             | 0     | 0    | 0     | 0     | 0     | 0     | 2     | 1     | 72    | 0     | 0     |
| ANIMALS.                     |       |      |       |       |       |       |       |       |       |       |       |
| Infusoria, Trachelomonas, .  | 0     | 0    | 0     | 0     | 0     | pr.   | 0     | 0     | 1     | 0     | 0     |
| Miscellaneous, Zoöglonæ, . . | 0     | 0    | 0     | 0     | 3     | 4     | 2     | 2     | 76    | 50    | 1     |
| TOTAL, . . . . .             | 0     | 0    | 3     | 46    | 3     | 4     | 17    | 5     | 449   | 50    | 5     |

## HYDE PARK AND MILTON.

## Chemical Examination of Water from Faucets in Milton, supplied from the Works of the Hyde Park Water Company.

[Parts per 100,000.]

| Number  | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             |           | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albuminoid. | Chlorine. | Nitrates.   | Nitrites. |                  |           |       |
| 1893.   |                     |             |            |        |                         |          |             |           |             |           |                  |           |       |
| 9939    | Jan. 25             | None.       | None.      | 0.00   | 8.85                    | .0004    | .0022       | 1.28      | .0850       | .0000     | .0584            | 4.4       | .0010 |
| 10050   | Feb. 27             | None.       | None.      | 0.03   | 8.25                    | .0008    | .0018       | 1.20      | .0850       | .0000     | .0504            | 4.3       | .0000 |
| 10153   | Mar. 22             | None.       | V. slight. | 0.00   | 8.10                    | .0000    | .0020       | 1.11      | .0800       | .0000     | .0504            | 8.6       | .0000 |
| 10210   | Apr. 4              | None.       | Slight.    | 0.00   | 7.25                    | .0000    | .0018       | 0.89      | .0900       | .0001     | .0387            | 2.9       | .0043 |
| 10357   | May 4               | None.       | None.      | 0.02   | 7.75                    | .0006    | .0044       | 0.92      | .1100       | .0000     | .0347            | 3.2       | .0025 |
| 10497   | June 7              | None.       | None.      | 0.00   | 6.90                    | .0004    | .0010       | 0.96      | .0800       | .0000     | .0469            | 12.9      | .0050 |
| 10614   | July 5              | None.       | None.      | 0.03   | 7.60                    | .0010    | .0018       | 1.09      | .0800       | .0000     | .0803            | 3.6       | .0000 |
| 10768   | Aug. 8              | None.       | None.      | 0.05   | 8.80                    | .0004    | .0026       | 1.31      | .0900       | .0000     | .0514            | 3.3       | .0000 |
| 11047   | Sept. 18            | None.       | None.      | 0.02   | 8.70                    | .0010    | .0040       | 1.28      | .0900       | .0000     | .1107            | 3.5       | .0000 |
| 11220   | Oct. 17             | None.       | None.      | 0.00   | 9.00                    | .0000    | .0030       | 1.33      | .0900       | .0000     | .0672            | 3.8       | .0000 |
| 11374   | Nov. 21             | None.       | None.      | 0.00   | 8.55                    | .0000    | .0028       | 1.35      | .1000       | .0000     | .1050            | 3.6       | .0000 |
| 11514   | Dec. 18             | None.       | None.      | 0.00   | 9.10                    | .0000    | .0025       | 1.40      | .0800       | .0000     | .1053            | 3.8       | .0000 |
| Av..... |                     |             |            | 0.01   | 8.24                    | .0004    | .0025       | 1.18      | .0858       | .0000     | .0733            | 3.6       | .0004 |

Odor, none. — The samples were collected from faucets on Adams Street, generally in the office of the Milton Water Company.

## Microscopical Examination.

No. 10210, Fungus, *Crenothrix*, 8.Nos. 10357, 10768 and 11220, Miscellaneous, *Zoëglæa*, 2.

No organisms were found in the remaining samples.

## Chemical Examination of Water from Three of the New Tubular Wells added to the Works of the Hyde Park Water Company in 1893.

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |                   |        | Residue on Evaporation. | AMMONIA. |             |           | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------------|-------------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.        | Sediment.         | Color. |                         | Free.    | Albuminoid. | Chlorine. | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1893.</b>        |                   |                   |        |                         |          |             |           |             |           |                  |           |       |
| 10455   | May 29              | Distinct.         | Cons., yellowish. | 0.05   | 7.80                    | .0456    | .0018       | .77       | .2000       | .0005     | .0375            | 1.9       | .0070 |
| 10456   | May 29              | None.             | V. slight.        | 0.01   | 4.10                    | .0000    | .0004       | .73       | .0300       | .0000     | .0113            | 1.3       | .0050 |
| 10457   | May 29              | Distinct, clayey. | Cons., clayey.    | 0.01   | 5.10                    | .0008    | .0008       | .94       | .0500       | .0000     | .0263            | 1.4       | .0050 |
| Av...   | .....               | .....             | .....             | 0.02   | 5.67                    | .0155    | .0010       | .81       | .1000       | .0002     | .0250            | 1.5       | .0290 |

Odor, none. — The first sample was collected from well No. 5, one of the wells nearest the river and distant from it about sixty-four feet; the second sample, from well No. 14, one of the wells near the middle of the group and distant about one hundred and four feet from the river; the last sample, from well No. 36, one of the wells farthest from the river and distant from it about one hundred and ninety-six feet.

## Microscopical Examination.

No. 10455, Miscellaneous, *Zoëglæa*, 144.No. 10456, Diatomaceæ, *Fragilaria*, 10.

No. 10457, No organisms.

## HYDE PARK AND MILTON.

*Chemical Examination of Water from the Neponset River at Hyde Park.*

[Parts per 100,000.]

| Number | Date of Collection. | APPEARANCE.         |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|--------|---------------------|---------------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|        |                     | Turbidity.          | Sediment.         | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|        |                     |                     |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1893.  |                     |                     |                   |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 9870   | Jan. 11             | Distinct,<br>milky. | Cons.             | 1.10   | 9.30                            | 2.70                 | .0104    | .0312       | .0256      | .0056           | 1.50      | .1100          | .0002     | .9464            | 2.4       |
| 9988   | Feb. 8              | Decided,<br>clayey. | Cons.             | 0.65   | 6.70                            | 2.45                 | .0138    | .0294       | .0244      | .0050           | 0.90      | .0200          | .0001     | .6971            | 2.3       |
| 10089  | Mar. 7              | Distinct.           | Cons.,<br>dark.   | 1.20   | 7.15                            | 2.80                 | .0018    | .0264       | .0218      | .0046           | 0.82      | .0090          | .0002     | 1.0368           | 3.1       |
| 10223  | Apr. 10             | V. slight.          | Slight.           | 1.00   | 5.15                            | 1.45                 | .0002    | .0192       | .0166      | .0026           | 0.58      | .0030          | .0001     | .7665            | 1.6       |
| 10372  | May 9               | V. slight.          | Slight.           | 1.20   | 4.80                            | 1.85                 | .0004    | .0242       | .0214      | .0028           | 0.43      | .0000          | .0000     | 1.0512           | 1.1       |
| 10492  | June 7              | Slight.             | Cons.,<br>rusty.  | 1.70   | 7.30                            | 2.40                 | .0192    | .0322       | .0278      | .0044           | 0.91      | .0050          | .0003     | 1.0439           | 3.2       |
| 10642  | July 11             | Distinct.           | Cons.,<br>rusty.  | 1.30   | 8.40                            | 2.60                 | .0116    | .0612       | .0324      | .0288           | 1.52      | .0050          | .0002     | 1.2848           | 3.0       |
| 10757  | Aug. 9              | Slight,             | Heavy,<br>rusty.  | 1.20   | 8.75                            | 3.25                 | .0058    | .0332       | .0264      | .0068           | 1.08      | .0030          | .0001     | 1.0309           | 2.7       |
| 10987  | Sept. 7             | Slight.             | Slight,<br>brown. | 1.10   | 8.75                            | 2.50                 | .0278    | .0296       | .0250      | .0046           | 1.56      | .0070          | .0040     | .7878            | 2.9       |
| 11136  | Oct. 3              | Distinct.           | Cons.,<br>rusty.  | 0.85   | 9.70                            | 2.25                 | .0710    | .0306       | .0264      | .0042           | 2.36      | .0000          | .0004     | .5852            | 2.6       |
| 11317  | Nov. 9              | Slight.             | Cons.             | 1.50   | 8.70                            | 3.10                 | .0044    | .0350       | .0314      | .0036           | 1.38      | .0070          | .0003     | 1.2720           | 2.5       |
| Av.    | .....               | .....               | .....             | 1.16   | 7.70                            | 2.49                 | .0151    | .0320       | .0254      | .0066           | 1.19      | .0154          | .0005     | .9548            | 2.4       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |       |      |       |       |       |       |      |       |       |       |     |
|---|-------|---|---|------|-------|------|-------|-------|-------|-------|------|-------|-------|-------|-----|
| - | 1887* | - | - | 1.19 | 8.35  | 2.30 | .0053 | .0400 | -     | -     | 0.99 | .0080 | -     | -     | -   |
| - | 1888  | - | - | 1.02 | 6.77  | 2.27 | .0030 | .0324 | -     | -     | 0.83 | .0095 | .0002 | -     | -   |
| - | 1891† | - | - | 1.48 | 10.34 | 3.45 | .0190 | .0510 | .0413 | .0097 | 1.16 | .0065 | .0003 | -     | 3.3 |
| - | 1892‡ | - | - | 0.90 | 13.30 | 2.85 | .0260 | .0324 | .0286 | .0038 | 2.31 | .0090 | .0012 | -     | 4.4 |
| - | 1893  | - | - | 1.16 | 7.70  | 2.49 | .0151 | .0320 | .0254 | .0066 | 1.19 | .0154 | .0005 | .9548 | 2.4 |

\* June to December.

† August and September.

‡ July.

NOTE to analyses of 1893: Iron, .0304. Odor, generally decidedly vegetable and musty, sometimes disagreeable or offensive. On heating, the odors are generally stronger and more frequently disagreeable or offensive. — The samples were collected from the river opposite the works of the Hyde Park Water Company. The river is not used as a source of water supply.



## HYDE PARK AND MILTON.

*Microscopical Examination of Water from the Neponset River at Hyde Park.*

[Number of organisms per cubic centimeter.]

|                             | 1893. |      |       |       |       |       |       |       |       |       |       |
|-----------------------------|-------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                             | Jan.  | Feb. | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  |
| Day of examination, . . .   | 13    | 9    | 8     | 12    | 10    | 9     | 13    | 10    | 9     | 5     | 11    |
| Number of sample, . . .     | 9870  | 9988 | 10089 | 10223 | 10372 | 10492 | 10642 | 10757 | 10987 | 11136 | 11317 |
| <b>PLANTS.</b>              |       |      |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .           | 0     | 1    | 1     | 19    | 42    | pr.   | 58    | 24    | 78    | 8     | 24    |
| Epithemia, . . .            | 0     | 0    | 0     | 0     | pr.   | 0     | 0     | 0     | 2     | 0     | 3     |
| Fragilaria, . . .           | 0     | 0    | 0     | 0     | 0     | 0     | 13    | 0     | 0     | 0     | 0     |
| Melosira, . . .             | 0     | 0    | 0     | 0     | 0     | 0     | 20    | 0     | 0     | 1     | 0     |
| Pinnularia, . . .           | 0     | 0    | 0     | 0     | 0     | 0     | 1     | 10    | 0     | 0     | 1     |
| Synedra, . . .              | 0     | 1    | 1     | 18    | 42    | 0     | 24    | 14    | 72    | 5     | 13    |
| Tabellaria, . . .           | 0     | 0    | 0     | 1     | 0     | pr.   | 0     | 0     | 2     | 0     | 7     |
| Algæ, . . .                 | 0     | 0    | pr.   | 1     | 0     | pr.   | 4     | 18    | 4     | 2     | 0     |
| Closterium, . . .           | 0     | 0    | pr.   | 1     | 0     | 0     | 0     | 2     | 2     | 0     | 0     |
| Protococcus, . . .          | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 12    | 0     | 0     | 0     |
| Scenedesmus, . . .          | 0     | 0    | 0     | 0     | 0     | pr.   | 1     | 0     | 2     | 2     | 0     |
| Spirogyra, . . .            | 0     | 0    | 0     | 0     | 0     | 0     | 3     | 4     | 0     | 0     | 0     |
| Fungi, . . .                | 822   | 0    | 268   | 158   | 0     | 960   | 440   | 1,560 | 176   | 444   | 40    |
| Crenothrix, . . .           | pr.   | 0    | 0     | 158   | 0     | 960   | 440   | 1,560 | 176   | 444   | 40    |
| Fungus, . . .               | 822   | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Leptothrix, . . .           | 0     | 0    | 268   | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| <b>ANIMALS.</b>             |       |      |       |       |       |       |       |       |       |       |       |
| Rhizopoda, . . .            | 0     | 0    | 0     | 0     | pr.   | 0     | 0     | 0     | 0     | 3     | 0     |
| Arcella, . . .              | 0     | 0    | 0     | 0     | pr.   | 0     | 0     | 0     | 0     | 1     | 0     |
| Diffugia, . . .             | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     |
| Infusoria, . . .            | 3     | 3    | 0     | 1     | 1     | 2     | 5     | 6     | 2     | 1     | 3     |
| Dinobryon cases, . . .      | 0     | 0    | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Euglena, . . .              | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     |
| Monas, . . .                | 0     | 3    | 0     | 0     | 0     | 2     | 3     | 6     | 1     | 0     | 1     |
| Peridinium, . . .           | 3     | 0    | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 1     | 2     |
| Trachelomonas, . . .        | 0     | 0    | 0     | 0     | 0     | 0     | 2     | 0     | 1     | 0     | 0     |
| Miscellaneous, Zoöglæa, . . | 550   | 276  | 406   | 76    | 0     | 620   | 1,400 | 2,480 | 100   | 70    | 180   |
| TOTAL, . . .                | 1,475 | 280  | 675   | 255   | 43    | 1,582 | 1,907 | 4,090 | 358   | 526   | 247   |

## IPSWICH.

IPSWICH.

*Chemical Examination of Water from Dow's Brook and Egypt River, Ipswich.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 11226   | 1893.<br>Oct. 18    | V. slight.  | V. slight. | 0.28   | 6.80                            | 1.80                 | .0000    | .0058       | .0034      | .0024           | .78       | .0240          | .0000     | 0.2508           | 2.5       |
| 11225   | Oct. 18             | V. slight.  | Slight.    | 1.40   | 8.35                            | 2.90                 | .0012    | .0226       | .0212      | .0014           | .88       | .0050          | .0000     | 1.0260           | 2.9       |

No. 11226, iron, .0300; No. 11225, iron, .0150. Odor of the first sample, none, becoming faintly vegetable on heating; of the last sample, distinctly vegetable. — The first sample was collected from Dow's Brook at a point a short distance above its mouth; the last sample, from Egypt River or Bull Brook, a short distance above the mouth of Dow's Brook. The samples were collected during an investigation for a water supply for Ipswich.

*Microscopical Examination.*

No. 11226. Diatomaceæ, *Synedra*, 1. Fungi, *Crenothrix*, 88. Miscellaneous, *Zoëglæa*, 12. Total, 51.

No. 11225. Diatomaceæ, *Asterionella*, 1; *Tabellaria*, 2. Fungi, *Crenothrix*, 46. Miscellaneous, *Zoëglæa*, 1. Total, 50.

## WATER SUPPLY OF KINGSTON.

The advice of the State Board of Health to the town of Kingston, with reference to taking an additional supply of water for the town from Jones River, may be found on page 21 of this volume.

## LAKEVILLE.

*Chemical Examination of Water from Long Pond, Lakeville.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
|         | <b>1893.</b>        |             |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 10660   | July 12             | V. slight.  | V. slight  | 1.10   | 3.75                            | 2.20                 | .0000    | .0234       | .0202      | .0032           | .42       | .0000          | .0000     | .8637            | 0.3       |
| 10708   | July 26             | V. slight.  | Slight.    | 1.00   | 4.50                            | 2.25                 | .0000    | .0182       | .0162      | .0020           | .39       | .0000          | .0000     | .8066            | 0.5       |
| 10769   | Aug. 9              | Slight.     | Slight.    | 0.75   | 3.35                            | 1.80                 | .0000    | .0132       | .0110      | .0022           | .44       | .0000          | .0000     | .8058            | 0.5       |
| 10948   | Aug. 31             | Slight.     | Slight.    | 0.70   | 3.35                            | 1.85                 | .0000    | .0148       | .0126      | .0022           | .44       | .0000          | .0000     | .7426            | 0.2       |
| 10986   | Sept. 6             | V. slight.  | V. slight. | 0.70   | 3.30                            | 1.50                 | .0000    | .0132       | .0116      | .0016           | .45       | .0000          | .0000     | .6825            | 0.2       |
| Av.     | .....               | .....       | .....      | 0.85   | 3.65                            | 1.92                 | .0000    | .0166       | .0144      | .0022           | .43       | .0018          | .0000     | .7812            | 0.3       |

Iron, .0050. Odor of Nos. 10708 and 10948, vegetable; of the remaining samples, none. — The samples were collected from the pond five feet beneath the surface, in connection with an investigation for an additional water supply for New Bedford.

*Microscopical Examination.*

The number of organisms per cubic centimeter found in these samples varied from eighty in the first to three in the last, and averaged forty-eight.

**HATFIELD.***Chemical Examination of Water from Running Gutter Brook, Hatfield.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13826   | 1895.<br>Feb. 15    | None.       | Cons., earthy. | .08    | 3.95                    | 0.85              | .0000    | .0026       | .0012      | .0014      | .10       | .0120       | .0000     | .1000            | 1.3       |

Odor, faintly vegetable. — The sample was collected from the brook at the first road crossing above its junction with Broad Brook, and a short distance below the site of a proposed reservoir.

*Microscopical Examination.*

Diatomaceæ, *Cocconeis*, 1. Algae, *Protococcus*, 1. Total, 2.

**WATER SUPPLY OF HAVERHILL.**

In 1895 an additional supply of water was introduced into the city of Haverhill from East Meadow River in the north-easterly part of the city, and a storage reservoir was constructed upon the stream at Millvale, about half a mile from the point where it enters the Merrimack River.

The reservoir has an area of about 50 acres and a capacity of about 125,000,000 gallons. Its maximum depth at high water is 15 feet and its average depth 7 feet. It was thoroughly prepared for the storage of water by removing the soil, mud and vegetable matter from the area to be flowed.

The water from this source is pumped into the easterly end of Kenoza Lake through a 24-inch main about one mile in length, the surface of Kenoza Lake at high water being 18 feet above the high-water level of the Millvale Reservoir.

The watershed of East Meadow River tributary to the Millvale Reservoir has an area of 7.75 square miles, on which there is a very small population. There is one small pond on the watershed about 3 miles above the reservoir, and there is a considerable area of swamp in the vicinity of the river, a large portion being located within a short distance of the reservoir.

## LAWRENCE.

## WATER SUPPLY OF LAWRENCE.

As already stated in a previous portion of this report (page 3), a filter having an area of two and a half acres was constructed by the city of Lawrence during the past year, at a cost of about sixty-five thousand dollars, and since its completion in September the water supplied to the city has been filtered.

The reply of the Board to an application from the city of Lawrence for information as to the results of the filtration of its water supply, after the filter had been in use a little more than two months, may be found on page 22 of this volume.

A more complete description of the filter with a statement of the results obtained by its use will be found in a subsequent portion of this report, also additional analyses of the Lawrence water made at the Lawrence Experiment Station.

*Chemical Examination of Water from the Merrimack River above Lawrence, opposite the Intake of the Lawrence Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------|--------|-------------------------|-------------------|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                  | Loss on ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                   |        |                         |                   |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |           |
| 1893.   |                     |             |                   |        |                         |                   |          |             |            |                 |           |             |           |                  |           |
| 9893    | Jan. 18             | Distinct.   | Slight.           | 0.40   | 4.35                    | 1.70              | .0080    | .0186       | .0162      | .0024           | .27       | .0070       | .0003     | .5110            | 1.3       |
| 10019   | Feb. 15             | Distinct.   | Slight.           | 0.45   | 3.75                    | 1.70              | .0012    | .0238       | .0180      | .0058           | .18       | .0120       | .0000     | .5272            | 1.1       |
| 10125   | Mar. 15             | Distinct.   | Cons.,<br>clayey. | 0.45   | 3.00                    | 1.10              | .0050    | .0230       | .0150      | .0080           | .16       | .0090       | .0001     | .5535            | 0.9       |
| 10272   | Apr. 19             | V. slight.  | Cons.,<br>clayey. | 0.45   | 3.00                    | 1.25              | .0010    | .0100       | .0102      | .0058           | .10       | .0070       | .0001     | .4964            | 0.6       |
| 10410   | May 17              | Distinct.   | Cons.,<br>earthy. | 0.55   | 2.75                    | 1.25              | .0000    | .0154       | .0138      | .0016           | .14       | .0180       | .0001     | .5584            | 0.6       |
| 10543   | June 21             | Slight.     | Cons.             | 0.33   | 3.90                    | 1.30              | .0062    | .0176       | .0158      | .0018           | .18       | .0050       | .0002     | .4424            | 1.1       |
| 10679   | July 19             | V. slight.  | Cons.,<br>brown.  | 0.12   | 4.00                    | 1.65              | .0124    | .0208       | .0160      | .0048           | .24       | .0030       | .0003     | .3744            | 1.8       |
| 10878   | Aug. 23             | Slight.     | Cons.,<br>green.  | 0.20   | 4.15                    | 1.60              | .0098    | .0166       | .0108      | .0058           | .30       | .0050       | .0001     | .4369            | 1.1       |
| 11063   | Sept. 20            | Slight.     | Slight.           | 0.38   | 4.15                    | 1.90              | .0092    | .0170       | .0146      | .0024           | .19       | .0090       | .0001     | .4100            | 1.3       |
| 11236   | Oct. 23             | Distinct.   | Slight.           | 1.00   | 5.35                    | 2.15              | .0102    | .0178       | .0148      | .0030           | .23       | .0080       | .0006     | .8854            | 1.4       |
| 11371   | Nov. 22             | Slight.     | Cons.             | 0.35   | 3.95                    | 1.15              | .0024    | .0132       | .0108      | .0024           | .22       | .0090       | .0004     | .5586            | 1.3       |
| 11528   | Dec. 20             | Slight.     | Slight.           | 0.40   | 4.00                    | 1.00              | .0030    | .0178       | .0128      | .0050           | .21       | .0100       | .0001     | .5994            | 0.9       |
| Av.     | .....               | .....       | .....             | 0.42   | 3.86                    | 1.48              | .0057    | .0181       | .0141      | .0040           | .20       | .0081       | .0002     | .5295            | 1.1       |

Iron, .0139. Odor, vegetable and musty.—The samples were collected from the river opposite the intake of the Lawrence Water Works, about one foot beneath the surface. For a record of the quantity of water flowing in the river on dates when samples of water were collected for analysis, see page 186. For a summary of the analyses of previous years, see "Merrimack River" in the chapter on "Examination of Rivers."

**LAWRENCE.**

*Microscopical Examination of Water from the Merrimack River above Lawrence, opposite the Intake of the Lawrence Water Works.*

[Number of organisms per cubic centimeter.]

|                                    | 1893. |       |       |       |       |       |       |       |       |       |       |       |
|------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                    | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, .              | 20    | 16    | 17    | 20    | 18    | 22    | 21    | 25    | 22    | 24    | 23    | 22    |
| Number of sample, .                | 9893  | 10019 | 10125 | 10272 | 10410 | 10543 | 10679 | 10878 | 11063 | 11236 | 11371 | 11528 |
| <b>PLANTS.</b>                     |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>Diatomaceæ,</b> . .             | 6     | 38    | 51    | 18    | 83    | 236   | 278   | 132   | 27    | 55    | 9     | 14    |
| Asterionella, . .                  | 1     | 2     | 3     | 0     | 13    | 0     | 5     | 24    | 5     | 0     | 3     | 0     |
| Cyclotella, . .                    | 1     | 20    | 0     | 0     | 2     | 2     | 0     | 1     | 0     | 0     | 0     | 0     |
| Diatoma, . .                       | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 0     | 2     | 2     | 0     | 0     |
| Fragilaria, . .                    | 0     | 0     | 0     | 2     | 4     | 20    | 0     | 0     | 0     | 0     | 0     | 0     |
| Melosira, . .                      | 0     | 2     | 19    | 7     | 4     | 12    | 0     | 0     | 0     | 8     | 0     | 12    |
| Meridion, . .                      | 0     | 1     | 0     | 2     | 4     | 6     | 0     | 0     | 0     | 0     | 0     | 0     |
| Nauicula, . .                      | 0     | 5     | 3     | 5     | 14    | 0     | 0     | 1     | 0     | 0     | 0     | 0     |
| Pinnularia, . .                    | 0     | 0     | 4     | 0     | 0     | 0     | 1     | 1     | 0     | 0     | 1     | 0     |
| Synedra, . .                       | 3     | 5     | 4     | 2     | 34    | 192   | 184   | 100   | 20    | 44    | 3     | 2     |
| Tabellaria, . .                    | 1     | 0     | 18    | 0     | 8     | 10    | 84    | 5     | 0     | 1     | 2     | 0     |
| <b>Algae,</b> . . . .              | 0     | 0     | 0     | 1     | 0     | 7     | 16    | 19    | 18    | 1     | 1     | 0     |
| Chlorococcus, . .                  | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 7     | 0     | 0     | 0     | 0     |
| Protooccus, . .                    | 0     | 0     | 0     | 0     | 0     | 4     | 8     | 5     | 0     | 0     | 0     | 0     |
| Raphidium, . .                     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 8     | 0     | 0     | 0     |
| Scenedesmus, . .                   | 0     | 0     | 0     | 0     | 0     | 1     | 4     | 3     | 2     | 0     | 0     | 0     |
| Stauroneis, . .                    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 8     | 0     | 0     | 0     |
| Zoopores, . .                      | 0     | 0     | 0     | 1     | 0     | 2     | 4     | 0     | 0     | 1     | 1     | 0     |
| <b>Fungi, Crenothrix,</b> .        | 0     | 0     | 0     | 0     | 8     | 44    | 9     | 0     | 64    | 32    | 0     | 1     |
| <b>ANIMALS.</b>                    |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>Rhizopoda, Amœba,</b> .         | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| <b>Infusoria,</b> . . . .          | 1     | 0     | 0     | 0     | 2     | 2     | 37    | 23    | 4     | 0     | 0     | 0     |
| Dinobryon cases, . .               | 1     | 0     | 0     | 0     | 2     | 0     | 32    | 20    | 0     | 0     | 0     | 0     |
| Euglypha, . .                      | 0     | 0     | 0     | 0     | 0     | 0     | 3     | 0     | 0     | 0     | 0     | 0     |
| Monas, . .                         | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     |
| Peridinium, . .                    | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 1     | 2     | 0     | 0     | 0     |
| Synura, . .                        | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 1     | 0     | 0     | 0     | 0     |
| Trachelomonas, . .                 | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     |
| <b>Vermes,</b> . . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 6     | 1     | 0     | 0     | 0     | 0     |
| Anurea, . .                        | 0     | 0     | 0     | 0     | 0     | 0     | 3     | 1     | 0     | 0     | 0     | 0     |
| Rotatorian ova, . .                | 0     | 0     | 0     | 0     | 0     | 0     | 3     | 0     | 0     | 0     | 0     | 0     |
| <b>Miscellaneous, Zoöglæa,</b> 140 | 12    | 800   | 104   | 2     | 6     | 80    | 200   | 56    | 32    | 40    | 64    |       |
| <b>TOTAL,</b> . . . .              | 147   | 50    | 853   | 123   | 95    | 295   | 426   | 375   | 169   | 120   | 50    | 79    |

## LAWRENCE.

*Chemical Examination of Water from the Force Main at the Pumping Station of the Lawrence Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |        |             |            | Chlorine.  | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------|--------|-------------------------|-------------------|----------|--------|-------------|------------|------------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                  | Loss on Ignition. | Free.    | Total. | Albuminoid. | Dissolved. | Suspended. | Nitrates.   | Nitrites. |                  |           |
| 9594    | 1893.<br>Jan. 18    | Distinct.   | Slight.           | 0.42   | 4.00                    | 1.40              | .0054    | .0166  | .0148       | .0018      | .30        | .0050       | .0001     | .5475            | 1.3       |
| 10020   | Feb. 15             | Distinct.   | Slight.           | 0.43   | 3.60                    | 1.40              | .0006    | .0216  | .0184       | .0032      | .18        | .0120       | .0000     | .5610            | 0.9       |
| 10126   | Mar. 15             | Distinct.   | Cons.,<br>earthy. | 0.40   | 3.25                    | 1.20              | .0052    | .0240  | .0122       | .0118      | .20        | .0150       | .0001     | .5165            | 0.9       |
| 10273   | Apr. 19             | Slight.     | Cons.,<br>earthy. | 0.48   | 3.00                    | 1.10              | .0014    | .0182  | .0096       | .0056      | .09        | .0050       | .0001     | .4672            | 0.8       |
| 10412   | May 17              | Distinct.   | Heavy,<br>earthy. | 0.60   | 2.80                    | 1.25              | .0000    | .0192  | .0138       | .0054      | .12        | .0100       | .0001     | .5329            | 0.8       |
| 10544   | June 21             | Slight.     | Cons.             | 0.35   | 4.20                    | 1.50              | .0066    | .0196  | .0146       | .0050      | .17        | .0030       | .0002     | .4424            | 0.9       |
| 10680   | July 19             | Slight.     | Cons.,<br>earthy. | 0.12   | 4.25                    | 1.80              | .0108    | .0200  | .0166       | .0034      | .24        | .0050       | .0003     | .3182            | 1.7       |
| 10879   | Aug. 23             | Slight.     | Cons.,<br>green.  | 0.18   | 4.55                    | 1.85              | .0102    | .0186  | .0150       | .0036      | .32        | .0050       | .0002     | .4029            | 1.1       |
| *11064  | Sept. 20            | Distinct.   | Slight.           | 0.05   | 13.70                   | 2.25              | .0708    | .0104  | .0078       | .0026      | .47        | .1200       | .0035     | .1640            | 8.1       |
| 11222   | Oct. 17             | Slight.     | None.             | 0.18   | 5.75                    | 1.40              | .0014    | .0080  | .0074       | .0006      | .24        | .0250       | .0002     | .2128            | 2.1       |
| 11372   | Nov. 22             | V. slight.  | None.             | 0.30   | 6.05                    | 1.00              | .0036    | .0082  | .0064       | .0018      | .33        | .0350       | .0007     | .4326            | 3.1       |
| 11529   | Dec. 20             | V. slight.  | V. slight.        | 0.33   | 5.50                    | 1.05              | .0090    | .0100  | .0078       | .0022      | .26        | .0270       | .0003     | .4779            | 2.6       |
| Av.     | .....               | .....       | .....             | 0.35   | 4.27                    | 1.36              | .0049    | .0164  | .0124       | .0040      | .22        | .0134       | .0002     | .4465            | 1.5       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | †1887 | - | - | 0.43 | 5.48 | 1.34 | .0017 | .0206 | -     | -     | .22 | .0140 | -     | -     | -   |
| - | 1888  | - | - | 0.28 | 4.31 | 1.09 | .0024 | .0159 | -     | -     | .19 | .0160 | .0002 | -     | -   |
| - | 1889  | - | - | 0.28 | 3.22 | 0.99 | .0029 | .0175 | .0145 | .0030 | .19 | .0111 | .0002 | -     | -   |
| - | 1890  | - | - | 0.34 | 4.03 | 1.51 | .0030 | .0162 | .0126 | .0036 | .18 | .0126 | .0002 | -     | -   |
| - | 1891  | - | - | 0.26 | 3.79 | 1.43 | .0039 | .0151 | .0119 | .0032 | .17 | .0165 | .0002 | -     | 1.2 |
| - | 1892  | - | - | 0.43 | 4.15 | 1.66 | .0035 | .0182 | .0146 | .0036 | .19 | .0137 | .0001 | -     | 1.4 |
| - | 1893  | - | - | 0.35 | 4.27 | 1.36 | .0049 | .0164 | .0124 | .0040 | .22 | .0134 | .0002 | .4465 | 1.5 |

\* This sample was collected on the day when the new filter was first operated, and represents the first water that passed through; it is abnormal on this account, and is therefore omitted from the average.  
† June to December.

NOTE to analyses of 1893: Iron, .0156. Odor, vegetable and musty, occasionally none. — The samples were collected from a faucet in the check-valve just beyond the pump, and, until September, 1893, represent a mixture of water from the river and the filter-gallery, though but a small portion of the water came from the latter source. Beginning with September, the samples represent water from the river after passing through the new filter. The odor of the filtered water was vegetable but never musty.

**LAWRENCE.***Microscopical Examination of Water from the Force Main at the Pumping Station of the Lawrence Water Works.*

[Number of organisms per cubic centimeter.]

|                             | 1892. |       |       |       |       |       |       |       |       |       |       |       |
|-----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                             | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . .     | 20    | 16    | 17    | 20    | 18    | 22    | 21    | 24    | 22    | 21    | 23    | 22    |
| Number of sample, . .       | 9894  | 10020 | 10126 | 10273 | 10412 | 10544 | 10680 | 10879 | 11064 | 11222 | 11372 | 11529 |
| <b>PLANTS.</b>              |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . .             | 2     | 24    | 30    | 34    | 103   | 173   | 226   | 123   | 5     | 11    | 0     | 0     |
| Asterionella, . .           | 2     | 0     | 0     | 0     | 4     | 3     | 2     | 0     | 0     | 0     | 0     | 0     |
| Cyclotella, . .             | 0     | 4     | 0     | 1     | 0     | 1     | 0     | 3     | 0     | 0     | 0     | 0     |
| Diatoma, . .                | 0     | 1     | 1     | 0     | 0     | 0     | 4     | 0     | 0     | 0     | 0     | 0     |
| Epithemia, . .              | 0     | 0     | 0     | 5     | 6     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Fragilaria, . .             | 0     | 0     | 4     | 0     | 2     | 0     | 27    | 11    | 0     | 2     | 0     | 0     |
| Melosira, . .               | 0     | 8     | 8     | 0     | 35    | 4     | 0     | 0     | 0     | 0     | 0     | 0     |
| Meridion, . .               | 0     | 0     | 1     | 0     | 4     | 1     | 0     | 0     | 0     | 0     | 0     | 0     |
| Navicula, . .               | 0     | 2     | 2     | 4     | 13    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Pinnularia, . .             | 0     | 0     | 4     | 1     | 0     | 0     | 1     | 1     | 0     | 2     | 0     | 0     |
| Synedra, . .                | 0     | 7     | 8     | 20    | 35    | 160   | 88    | 64    | 2     | 2     | 0     | 0     |
| Tabellaria, . .             | 0     | 2     | 2     | 3     | 4     | 4     | 104   | 44    | 3     | 5     | 0     | 0     |
| Algæ, . .                   | 0     | 0     | 0     | 0     | 0     | 14    | 0     | 12    | 0     | 0     | 0     | 0     |
| Chlorococcus, . .           | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 12    | 0     | 0     | 0     | 0     |
| Protococcus, . .            | 0     | 0     | 0     | 0     | 0     | 14    | 0     | 0     | 0     | 0     | 0     | 0     |
| Fungi, Crenothrix, . .      | 0     | 1     | 0     | 0     | 7     | 44    | 7     | 20    | 0     | 2     | 5     | 0     |
| <b>ANIMALS.</b>             |       |       |       |       |       |       |       |       |       |       |       |       |
| Rhizopoda, Arcella, . .     | 0     | 0     | 0     | 0     | 0     | 1     | 1     | 0     | 0     | 0     | 0     | 0     |
| Infusoria, . .              | 2     | 2     | 0     | 0     | 1     | 1     | 5     | 7     | 1     | 0     | 0     | 0     |
| Dinobryon cases, . .        | 2     | 2     | 0     | 0     | 0     | 0     | 0     | 6     | 0     | 0     | 0     | 0     |
| Monas, . .                  | 0     | 0     | 0     | 0     | 1     | 1     | 3     | 1     | 1     | 0     | 0     | 0     |
| Synura, . .                 | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     |
| Miscellaneous, Zoöglæa, . . | 244   | 100   | 576   | 28    | 0     | 2     | 316   | 360   | 600   | 3     | 4     | 0     |
| TOTAL, . .                  | 243   | 127   | 606   | 62    | 111   | 235   | 555   | 522   | 606   | 16    | 9     | 0     |

## LAWRENCE.

*Chemical Examination of Water from the Distributing Reservoir of the Lawrence Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 9895    | 1893.<br>Jan. 18    | Distinct.   | Slight.    | 0.45   | 4.45                            | 1.80                 | .0058    | .0166       | .0138      | .0028           | .28       | .0070          | .0002     | .5548            | 1.3       |
| 10021   | Feb. 15             | Slight.     | Slight.    | 0.32   | 4.15                            | 1.60                 | .0098    | .0198       | .0174      | .0024           | .28       | .0150          | .0001     | .4635            | 1.5       |
| 10127   | Mar. 15             | Slight.     | Slight.    | 0.40   | 4.05                            | 1.20                 | .0070    | .0160       | .0124      | .0026           | .25       | .0150          | .0000     | .4869            | 1.3       |
| 10274   | Apr. 19             | V. slight.  | Slight.    | 0.40   | 2.85                            | 1.20                 | .0020    | .0120       | .0098      | .0022           | .11       | .0050          | .0001     | .4234            | 0.6       |
| 10411   | May 17              | Slight.     | Slight.    | 0.43   | 2.40                            | 0.80                 | .0014    | .0150       | .0110      | .0040           | .12       | .0180          | .0001     | .4562            | 0.8       |
| 10545   | June 21             | V. slight.  | Slight.    | 0.30   | 3.40                            | 1.35                 | .0028    | .0172       | .0128      | .0044           | .18       | .0070          | .0002     | .4029            | 0.9       |
| 10681   | July 19             | V. slight.  | V. slight. | 0.10   | 3.75                            | 1.75                 | .0094    | .0150       | .0134      | .0016           | .23       | .0050          | .0002     | .2886            | 1.1       |
| 10880   | Aug. 23             | V. slight.  | Slight.    | 0.18   | 4.50                            | 1.60                 | .0132    | .0170       | .0124      | .0046           | .28       | .0070          | .0001     | .3476            | 1.4       |
| 11065   | Sept. 20            | Slight.     | Slight.    | 0.35   | 4.95                            | 1.80                 | .0118    | .0158       | .0140      | .0018           | .26       | .0150          | .0001     | .4223            | 2.7       |
| 11224   | Oct. 17             | Slight.     | Slight.    | 0.15   | 5.70                            | 1.45                 | .0000    | .0120       | .0080      | .0040           | .26       | .0220          | .0000     | .2242            | 2.1       |
| 11373   | Nov. 22             | V. slight.  | None.      | 0.30   | 5.05                            | 1.20                 | .0012    | .0094       | .0078      | .0016           | .26       | .0180          | .0005     | .5040            | 2.3       |
| 11530   | Dec. 20             | Slight.     | Slight.    | 0.30   | 5.00                            | 1.30                 | .0026    | .0094       | .0080      | .0014           | .23       | .0200          | .0002     | .5022            | 2.2       |
| Av.     | .....               | .....       | .....      | 0.31   | 4.19                            | 1.42                 | .0048    | .0145       | .0117      | .0028           | .23       | .0128          | .0010     | .4231            | 1.5       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 0.36 | 4.10 | 1.00 | .0028 | .0162 | -     | -     | .19 | .0151 | -     | -     | -   |
| - | 1888  | - | - | 0.27 | 3.81 | 1.19 | .0032 | .0140 | -     | -     | .19 | .0167 | .0002 | -     | -   |
| - | 1889  | - | - | 0.25 | 3.18 | 0.93 | .0030 | .0150 | .0130 | .0020 | .18 | .0127 | .0003 | -     | -   |
| - | 1890  | - | - | 0.27 | 3.64 | 1.09 | .0032 | .0134 | .0108 | .0026 | .17 | .0150 | .0002 | -     | 1.6 |
| - | 1891  | - | - | 0.24 | 3.75 | 1.22 | .0032 | .0132 | .0106 | .0026 | .18 | .0184 | .0002 | -     | 1.2 |
| - | 1892  | - | - | 0.36 | 3.97 | 1.59 | .0037 | .0158 | .0132 | .0026 | .19 | .0138 | .0001 | -     | 1.3 |
| - | 1893  | - | - | 0.31 | 4.19 | 1.42 | .0048 | .0145 | .0117 | .0028 | .23 | .0128 | .0010 | .4231 | 1.5 |

\* June to December.

NOTE to analyses of 1893; Iron, .0117. Odor, generally distinctly vegetable, frequently mouldy. — The samples were collected from a faucet at the gate-house and represent water flowing out of the reservoir. After September 20, the reservoir was supplied with filtered water, and the mouldy odor was not noticed after that date.



**LAWRENCE.***Microscopical Examination of Water from the Distributing Reservoir of the Lawrence Water Works.*

[Number of organisms per cubic centimeter.]

|                           | 1893. |       |       |       |       |       |       |       |       |       |       |       |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                           | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, .     | 20    | 16    | 17    | 20    | 18    | 22    | 21    | 25    | 21    | 21    | 23    | 22    |
| Number of sample, .       | 9895  | 10021 | 10127 | 10274 | 10411 | 10545 | 10681 | 10880 | 11065 | 11224 | 11373 | 11530 |
| <b>PLANTS.</b>            |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . .           | 19    | 3     | 0     | 52    | 62    | 8     | 4     | 2     | 9     | 8     | 8     | 1     |
| Asterionella, . .         | 0     | 0     | 0     | 5     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Melosira, . . .           | 0     | 2     | 0     | 0     | 13    | 0     | 0     | 0     | 0     | 0     | 3     | 0     |
| Meridion, . . .           | 1     | 0     | 0     | 1     | 4     | 0     | 0     | 0     | 0     | 0     | pr.   | 0     |
| Navicula, . . .           | 3     | 1     | 0     | 2     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Synedra, . . .            | 3     | 0     | 0     | 44    | 36    | 8     | 0     | 0     | 7     | 5     | 5     | 0     |
| Tabellaria, . .           | 12    | 0     | 0     | 0     | 3     | 0     | 4     | 2     | 2     | 3     | 0     | 1     |
| Algæ, . . . .             | 0     | 1     | 0     | 3     | 9     | 32    | 128   | 86    | 134   | pr.   | 3     | 0     |
| Chlorococcus, .           | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 5     | 5     | 0     | 0     | 0     |
| Closterium, . .           | 0     | 0     | 0     | 0     | 1     | 7     | 0     | 1     | 1     | pr.   | 1     | 0     |
| Protooccus, . .           | 0     | 0     | 0     | 0     | 0     | 24    | 128   | 80    | 128   | 0     | 2     | 0     |
| Zoöspores, . .            | 0     | 1     | 0     | 3     | 8     | 1     | 0     | 0     | 0     | 0     | 0     | 0     |
| Fungi, Crenothrix, .      | 0     | 0     | 0     | 0     | 3     | 0     | 3     | 1     | 4     | pr.   | 1     | 0     |
| <b>ANIMALS.</b>           |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . .          | 1     | 0     | 2     | 0     | 0     | 0     | 0     | 2     | 0     | 2     | 0     | 0     |
| Monas, . . . .            | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     |
| Peridinium, . .           | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Trachelomonas, .          | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     |
| Miscellaneous, Zoöglas, . | 156   | 35    | 148   | 14    | 60    | 3     | 28    | 55    | 108   | 80    | 0     | 7     |
| TOTAL, . . . .            | 176   | 40    | 150   | 69    | 134   | 43    | 163   | 147   | 255   | 90    | 12    | 8     |

*Volume of Water flowing in the Merrimack River at Lawrence on the Dates when Samples of Water were collected for Analysis.*

| DATE.             | VOLUME FLOWING IN THE<br>MERRIMACK RIVER IN<br>CUBIC FEET PER SECOND. |                                                               | DATE.             | VOLUME FLOWING IN THE<br>MERRIMACK RIVER IN<br>CUBIC FEET PER SECOND. |                                                               |
|-------------------|-----------------------------------------------------------------------|---------------------------------------------------------------|-------------------|-----------------------------------------------------------------------|---------------------------------------------------------------|
|                   | Rate of<br>Flow during<br>Eleven<br>Hours of the<br>Day.              | Rate of<br>Flow during<br>the Whole<br>Twenty-<br>four Hours. |                   | Rate of<br>Flow during<br>Eleven<br>Hours of the<br>Day.              | Rate of<br>Flow during<br>the Whole<br>Twenty-<br>four Hours. |
| 1893.             |                                                                       |                                                               |                   |                                                                       |                                                               |
| Jan. 18, . . . .  | 4,590                                                                 | 2,770                                                         | July 19, . . . .  | 3,230                                                                 | 2,280                                                         |
| Feb. 15, . . . .  | 7,200                                                                 | 7,560                                                         | Aug. 23, . . . .  | 4,100                                                                 | 3,332                                                         |
| Mar. 15, . . . .  | 18,770                                                                | 22,160                                                        | Sept. 21, . . . . | 3,920                                                                 | 3,000                                                         |
| April 19, . . . . | 18,190                                                                | 17,400                                                        | Oct. 23, . . . .  | 4,850                                                                 | 3,900                                                         |
| May 17, . . . .   | 22,600                                                                | 21,900                                                        | Nov. 22, . . . .  | 3,230                                                                 | 2,280                                                         |
| June 21, . . . .  | 4,780                                                                 | 3,900                                                         | Dec. 20, . . . .  | 7,790                                                                 | 6,970                                                         |

## LEICESTER.

## WATER SUPPLY OF LEICESTER.

*Chemical Examination of Water from the Wells of the Leicester Water Supply District.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |            |        | Residue on Evaporation. | AMMONIA. |           | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------------|------------|--------|-------------------------|----------|-----------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.        | Sediment.  | Color. |                         | Free.    | Albimoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 10039   | 1893.<br>Feb. 21    | Decided, clayey.  | V. slight. | 0.50   | 5.10                    | .0000    | .0002     | .19       | .0070       | .0007     | .2347            | 2.6       | .1175 |
| 10275   | Apr. 19             | Distinct, clayey. | None.      | 0.50   | 5.00                    | .0006    | .0038     | .14       | .0100       | .0003     | .1971            | 1.6       | .0570 |
| 10540   | June 20             | V. slight.        | Slight.    | 0.18   | 4.20                    | .0000    | .0024     | .19       | .0500       | .0005     | .1239            | 1.5       | .0200 |
| 10898   | Aug. 28             | None.             | None.      | 0.00   | 5.50                    | .0006    | .0008     | .21       | .1000       | .0000     | .1011            | 2.2       | .0060 |
| 11250   | Oct. 24             | V. slight.        | None.      | 0.25   | 6.00                    | .0000    | .0018     | .19       | .0550       | .0000     | .1444            | 2.2       | .0330 |
| 11527   | Dec. 20             | None.             | None.      | 0.25   | 5.70                    | .0000    | .0044     | .21       | .0730       | .0000     | .1579            | 2.2       | .0185 |
| Av.     | .....               | .....             | .....      | 0.28   | 5.25                    | .0002    | .0032     | .19       | .0492       | .0003     | .1598            | 2.1       | .0420 |

Odor, of No. 10275, faintly musty, becoming stronger on heating; of No. 11527, faintly vegetable; of the remaining samples, none. — The first two samples were collected from a faucet supplied through 1,800 feet of two-inch wrought-iron pipe, leading from the end of a six-inch main; the remaining samples, from faucets in the village.

*Microscopical Examination of Water from the Wells of the Leicester Water Supply District.*

[Number of organisms per cubic centimeter.]

|                                   | 1893. |       |       |       |       |       |
|-----------------------------------|-------|-------|-------|-------|-------|-------|
|                                   | Feb.  | Apr.  | June. | Aug.  | Oct.  | Dec.  |
| Day of examination, . . . . .     | 23    | 20    | 22    | 29    | 25    | 22    |
| Number of sample, . . . . .       | 10039 | 10275 | 10540 | 10898 | 11250 | 11527 |
| PLANTS.                           |       |       |       |       |       |       |
| Diatomaceæ, . . . . .             | 2     | 3     | 0     | 2     | 157   | 24    |
| Asterionella, . . . . .           | 1     | 2     | 0     | 0     | 76    | 1     |
| Cyclotella, . . . . .             | 0     | 0     | 0     | 0     | 7     | 0     |
| Synedra, . . . . .                | 1     | 1     | 0     | 0     | 74    | 21    |
| Tabellaria, . . . . .             | 0     | 0     | 0     | 2     | 0     | 2     |
| Algae, Protococcus, . . . . .     | 0     | 0     | 0     | 0     | 36    | 0     |
| Fungi, Fungus, . . . . .          | 0     | 0     | 12    | 0     | 0     | 0     |
| ANIMALS.                          |       |       |       |       |       |       |
| Infusoria, Peridinium, . . . . .  | 0     | 0     | 0     | 0     | 1     | 1     |
| Miscellaneous, Zoöglæa, . . . . . | 32    | 4     | 14    | 3     | 0     | 1     |
| TOTAL, . . . . .                  | 34    | 7     | 26    | 5     | 194   | 26    |

## LEOMINSTER.

## WATER SUPPLY OF LEOMINSTER.

*Chemical Examination of Water from Haynes Reservoir, Leominster.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                  |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.        | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |                  |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 9909    | 1893.<br>Jan. 21    | Slight.     | Slight.          | 0.55   | 4.40                            | 2.45                 | .0114    | .0462       | .0352      | .0110           | .20       | .0030          | .0002     | .6993            | 1.1       |
| 10144   | Mar. 20             | Slight.     | Cons.            | 0.45   | 2.80                            | 1.20                 | .0184    | .0230       | .0180      | .0050           | .17       | .0050          | .0000     | .3528            | 0.6       |
| 10424   | May 22              | Distinct.   | Cons.            | 0.40   | 1.85                            | 1.05                 | .0004    | .0304       | .0154      | .0150           | .10       | .0030          | .0000     | .4575            | 0.0       |
| 10671   | July 17             | Distinct.   | Cons.,<br>green. | 0.15   | 2.60                            | 1.65                 | .0000    | .0428       | .0248      | .0180           | .12       | .0000          | .0000     | .5148            | 0.0       |
| 11054   | Sept. 19            | Decided.    | Cons.,<br>green. | 0.20   | 2.85                            | 1.70                 | .0000    | .0776       | .0268      | .0508           | .14       | .0030          | .0000     | .4387            | 0.3       |
| 11351   | Nov. 20             | Distinct.   | Cons.            | 0.18   | 3.40                            | 2.25                 | .0000    | .0572       | .0264      | .0308           | .13       | .0030          | .0001     | .5376            | 0.2       |
| Av.,    | .....               | .....       | .....            | 0.32   | 2.98                            | 1.72                 | .0050    | .0462       | .0244      | .0218           | .14       | .0028          | .0001     | .5001            | 0.4       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 0.58 | 3.61 | 2.00 | .0040 | .0647 | -     | -     | .13 | .0054 | -     | -     | -   |
| - | 1888  | - | - | 0.36 | 2.80 | 1.42 | .0023 | .0352 | -     | -     | .12 | .0075 | .0001 | -     | -   |
| - | 1889  | - | - | 0.27 | 2.35 | 0.94 | .0010 | .0426 | .0254 | .0172 | .11 | .0034 | .0001 | -     | -   |
| - | 1890  | - | - | 0.21 | 2.86 | 1.66 | .0003 | .0500 | .0210 | .0290 | .11 | .0063 | .0001 | -     | 0.6 |
| - | 1891  | - | - | 0.24 | 2.80 | 1.48 | .0005 | .0482 | .0231 | .0251 | .10 | .0097 | .0001 | -     | 0.2 |
| - | 1893  | - | - | 0.32 | 2.98 | 1.72 | .0050 | .0462 | .0244 | .0218 | .14 | .0028 | .0001 | .5001 | 0.4 |

\* June to December.

NOTE to analyses of 1893; Iron, .0133. Odor, generally distinctly vegetable, sometimes also unpleasant; on heating the odor is stronger, and in the first and last samples also disagreeable.—— The samples were collected from the reservoir near the gate-house at a depth of about one foot beneath the surface.

Ever since the examinations of the water of this reservoir were begun, in 1887, it has contained an abundant growth of organisms in the summer and autumn, which are the cause of the high albuminoid ammonia shown in the tables of analyses. The reservoir was formed by flooding 58 acres of land, a portion of it swamp, to a maximum depth of 12 feet, without removing the stumps of trees or the soil; and it is of interest to note that although the reservoir has been flooded for twenty years, the water has not shown any improvement in quality within the time covered by the examinations.

## LEOMINSTER.

*Microscopical Examination of Water from Haynes Reservoir, Leominster.*

[Number of organisms per cubic centimeter

|                                   | 1893. |        |       |       |       |       |
|-----------------------------------|-------|--------|-------|-------|-------|-------|
|                                   | Jan.  | March. | May.  | July. | Sept. | Nov.  |
| Day of examination, . . . . .     | 24    | 22     | 23    | 20    | 20    | 21    |
| Number of sample, . . . . .       | 9909  | 10144  | 10424 | 10671 | 11054 | 11351 |
| PLANTS.                           |       |        |       |       |       |       |
| Diatomaceæ, . . . . .             | 4     | 12     | 1,797 | 474   | 436   | 423   |
| Asterionella, . . . . .           | 0     | 0      | 96    | 17    | 10    | 116   |
| Melosira, . . . . .               | 0     | 0      | 740   | 196   | 352   | 112   |
| Synedra, . . . . .                | 0     | 9      | 1     | 1     | 4     | 3     |
| Tabellaria, . . . . .             | 4     | 3      | 960   | 260   | 70    | 192   |
| Cyanophyceæ, . . . . .            | 52    | 1      | 1     | 296   | 312   | 34    |
| Anabæna, . . . . .                | 0     | 0      | 0     | 28    | 0     | 0     |
| Clathrocystis, . . . . .          | 52    | 1      | 1     | 152   | 312   | 32    |
| Cœlosphaerium, . . . . .          | 0     | 0      | 0     | 116   | 0     | 2     |
| Algæ, . . . . .                   | 0     | 0      | 5     | 149   | 12    | 106   |
| Arthrodesmus, . . . . .           | 0     | 0      | 0     | 0     | 0     | 3     |
| Pediastrum, . . . . .             | 0     | 0      | 3     | 7     | 2     | 3     |
| Protocecus, . . . . .             | 0     | 0      | 0     | 108   | 10    | 10    |
| Raphidium, . . . . .              | 0     | 0      | 0     | 5     | 0     | 0     |
| Scenedesmus, . . . . .            | 0     | 0      | pr.   | 20    | 0     | 88    |
| Staurostrum, . . . . .            | 0     | 0      | 2     | 9     | 0     | 2     |
| Fungi, . . . . .                  | 5     | 0      | 0     | 3     | 0     | 0     |
| Fungus, . . . . .                 | 5     | 0      | 0     | 0     | 0     | 0     |
| Molds, . . . . .                  | 0     | 0      | 0     | 3     | 0     | 0     |
| ANIMALS.                          |       |        |       |       |       |       |
| Rhizopoda, Diffugia, . . . . .    | 0     | 14     | 0     | 0     | 0     | 0     |
| Infusoria, . . . . .              | 52    | 2      | 1     | 3     | 8     | 3     |
| Cryptomonas, . . . . .            | 0     | 2      | 0     | 0     | 0     | 0     |
| Dinobryon, . . . . .              | 8     | 0      | 0     | 0     | 0     | 0     |
| Peridinium, . . . . .             | 44    | 0      | 1     | 1     | 8     | 3     |
| Trachelomonas, . . . . .          | 0     | 0      | 0     | 2     | 0     | 0     |
| Vermes, . . . . .                 | 11    | 1      | 5     | 1     | 6     | 0     |
| Anurea, . . . . .                 | 0     | 1      | 5     | 1     | 4     | 0     |
| Polyarthra, . . . . .             | 11    | 0      | pr.   | 0     | 0     | 0     |
| Rotifer, . . . . .                | 0     | 0      | 0     | 0     | 2     | 0     |
| Miscellaneous, Zoögloæ, . . . . . | 424   | 4      | 22    | 0     | 0     | 0     |
| TOTAL, . . . . .                  | 548   | 34     | 1,831 | 926   | 774   | 566   |

## LEOMINSTER.

*Chemical Examination of Water from Morse Reservoir, Leominster.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 9910    | 1893.<br>Jan. 21    | V. slight.  | V. slight. | 0.65   | 4.00                            | 1.00                 | .0000    | .0180       | .0152      | .0028           | .22       | .0030          | .0003     | .6701            | 1.8       |
| 10143   | Mar. 20             | V. slight.  | Slight.    | 0.40   | 2.60                            | 1.20                 | .0016    | .0108       | .0062      | .0046           | .13       | .0070          | .0001     | .3744            | 0.5       |
| 10425   | May 22              | V. slight.  | Slight.    | 0.40   | 1.85                            | 1.10                 | .0000    | .0110       | .0088      | .0022           | .09       | .0030          | .0000     | .4650            | 0.0       |
| 10672   | July 17             | V. slight.  | Slight.    | 0.10   | 2.30                            | 1.35                 | .0020    | .0200       | .0164      | .0036           | -         | .0030          | .0000     | .4992            | 0.0       |
| 11055   | Sept. 19            | Slight.     | Slight.    | 0.25   | 2.85                            | 1.65                 | .0010    | .0234       | .0190      | .0044           | .14       | .0030          | .0000     | .4715            | 0.5       |
| 11350   | Nov. 20             | Slight.     | Slight.    | 0.62   | 2.75                            | 1.25                 | .0006    | .0220       | .0152      | .0068           | .24       | .0000          | .0001     | .6132            | 0.3       |
| Av.     | .....               | .....       | .....      | 0.40   | 2.73                            | 1.36                 | .0009    | .0175       | .0135      | .0041           | .16       | .0032          | .0001     | .5156            | 0.5       |

Iron, .0129. Odor, generally distinctly vegetable, becoming fainter on heating. — The samples were collected from the reservoir.

This reservoir was enlarged in 1891 by the construction of a new and higher dam, increasing its depth to 23 feet and its capacity from 7,000,000 to 40,000,000 gallons. It is said that all loam and vegetable matter was removed from the land flowed by raising the dam.

*Microscopical Examination of Water from Morse Reservoir, Leominster.*

[Number of organisms per cubic centimeter.]

|                               | 1893. |        |       |       |       |       |
|-------------------------------|-------|--------|-------|-------|-------|-------|
|                               | Jan.  | March. | May.  | July. | Sept. | Nov.  |
| Day of examination, . . . . . | 24    | 22     | 23    | 20    | 21    | 21    |
| Number of sample, . . . . .   | 9910  | 10143  | 10425 | 10672 | 11055 | 11350 |
| PLANTS.                       |       |        |       |       |       |       |
| Diatomaceæ, . . . . .         | pr.   | 2      | 148   | 22    | 28    | 301   |
| Asterionella, . . . . .       | 0     | 0      | 15    | 0     | 4     | 300   |
| Cyclotella, . . . . .         | 0     | 0      | 6     | 1     | 0     | 0     |
| Synedra, . . . . .            | pr.   | 2      | 124   | 20    | 4     | 1     |
| Tabellaria, . . . . .         | 0     | 0      | 3     | 1     | 20    | 0     |
| Algae, . . . . .              | 22    | 2      | 23    | 10    | 2     | 404   |
| Closterium, . . . . .         | 22    | 2      | 0     | 0     | 0     | 0     |
| Protococcus, . . . . .        | 0     | 0      | 20    | 4     | 0     | 400   |
| Raphidium, . . . . .          | 0     | 0      | 3     | 0     | 2     | 4     |
| Staurostrum, . . . . .        | 0     | 0      | 0     | 6     | 0     | 0     |
| Fungi, Molds, . . . . .       | 0     | 0      | 0     | 10    | 0     | 0     |

## LEOMINSTER.

*Microscopical Examination of Water from Morse Reservoir, Leominster*  
— Concluded.

[Number of organisms per cubic centimeter.]

|                                        | 1893. |        |      |       |       |      |
|----------------------------------------|-------|--------|------|-------|-------|------|
|                                        | Jan.  | March. | May. | July. | Sept. | Nov. |
| <b>ANIMALS.</b>                        |       |        |      |       |       |      |
| <b>Rhizopoda, Actinophrys, . . . .</b> | 0     | 0      | pr.  | 1     | 0     | 0    |
| <b>Infusoria, . . . . .</b>            | 9     | pr.    | 588  | 56    | 0     | 5    |
| Dinobryon, . . . . .                   | 8     | 0      | 0    | 0     | 0     | 0    |
| Dinobryon cases, . . . . .             | 0     | 0      | 588  | 56    | 0     | 0    |
| Peridinium, . . . . .                  | 0     | pr.    | pr.  | 0     | 0     | 5    |
| Synura, . . . . .                      | 1     | 0      | 0    | 0     | 0     | 0    |
| <b>Vermes, Rotifer, . . . . .</b>      | 0     | 0      | 0    | 0     | 5     | 0    |
| <b>Miscellaneous, Zoöglæa, . . . .</b> | 30    | 34     | 13   | 52    | 48    | 36   |
| <b>TOTAL, . . . . .</b>                | 61    | 38     | 772  | 151   | 83    | 746  |

**WATER SUPPLY OF LEXINGTON. — LEXINGTON WATER COMPANY.**

The advice of the State Board of Health to the Lexington Water Company, with reference to an additional water supply, may be found on page 23 of this volume.

*Chemical Examination of Water from the Covered Gallery of the Lexington Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |             |        | Residue on Evaporation. | AMMONIA. |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-------------|--------|-------------------------|----------|-----------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Settlement. | Color. |                         | Free.    | Alb-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         |                     |             |             |        |                         |          |                 |           |             |           |                  |           |       |
| 10278   | 1893.<br>Apr. 19    | None.       | Slight.     | 0.0    | 9.90                    | .0000    | .0010           | .87       | .6000       | .0002     | .0547            | 3.2       | .0100 |

Odor, none. — The sample was collected from the covered gallery, which is located 1,540 feet toward the village from the nearest of the original wells.

*Microscopical Examination.*

No organisms.

## HOLYOKE.

*Microscopical Examination of Water from Wright and Ashley Ponds, Holyoke—*  
Concluded.

[Number of organisms per cubic centimeter.]

|                                         | 1895. |      |      |       |       |      |      |
|-----------------------------------------|-------|------|------|-------|-------|------|------|
|                                         | Jan.  | Feb. | May. | June. | Sept. | Nov. | Dec. |
| <b>PLANTS—Con.</b>                      |       |      |      |       |       |      |      |
| <b>Cyanophyceæ,</b> . . . . .           | 0     | 0    | 0    | 13    | 200   | 0    | 0    |
| <i>Anabaena,</i> . . . . .              | 0     | 0    | 0    | 1     | 120   | 0    | 0    |
| <i>Chroococcus,</i> . . . . .           | 0     | 0    | 0    | 0     | 140   | 0    | 0    |
| <i>Microcystis,</i> . . . . .           | 0     | 0    | 0    | 12    | 0     | 0    | 0    |
| <b>Algæ,</b> . . . . .                  | 0     | 0    | 13   | 51    | 30    | 0    | 0    |
| <i>Protococcus,</i> . . . . .           | 0     | 0    | 13   | 25    | 30    | 0    | 0    |
| <i>Staurogenia,</i> . . . . .           | 0     | 0    | 0    | 25    | 0     | 0    | 0    |
| <b>ANIMALS.</b>                         |       |      |      |       |       |      |      |
| <b>Infusoria,</b> . . . . .             | 35    | 13   | 2    | 1     | 0     | 0    | 04   |
| Ciliated infusorian, . . . . .          | 0     | 0    | 1    | 0     | 0     | 0    | 0    |
| Dinobryon cases, . . . . .              | 0     | 0    | 0    | 1     | 0     | 0    | 0    |
| <i>Mallomonas,</i> . . . . .            | 5     | 0    | 0    | 0     | 0     | 0    | 0    |
| <i>Monas,</i> . . . . .                 | 0     | 0    | 1    | 0     | 0     | 0    | 0    |
| <i>Peridinium,</i> . . . . .            | 29    | 12   | 0    | 0     | 0     | 0    | 04   |
| <i>Trachelomonas,</i> . . . . .         | 1     | 1    | 0    | 0     | 0     | 0    | 0    |
| <b>Miscellaneous, Zoöglæ,</b> . . . . . | 2     | 15   | 50   | 0     | 0     | 0    | 0    |
| <b>TOTAL,</b> . . . . .                 | 40    | 28   | 161  | 421   | 306   | 0    | 04   |

*Chemical Examination of Water from Tucker and Manhan Brooks, Southampton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1893.   |                     |             |            |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 14795   | Aug. 9              | V. slight.  | V. slight. | .35    | 4.15                    | 1.25              | .0004    | .0110       | .0092      | .0018      | .16       | .0020       | .0000     | .4758            | 1.1       |
| 14935   | Aug. 28             | None.       | V. slight. | .12    | 3.80                    | 0.80              | .0014    | .0036       | .0030      | .0006      | .12       | .0000       | .0003     | .1482            | 1.3       |
| 14796   | Aug. 9              | V. slight.  | V. slight. | .15    | 4.70                    | 1.15              | .0014    | .0048       | .0040      | .0008      | .10       | .0030       | .0000     | .3042            | 2.7       |
| 14934   | Aug. 28             | None.       | V. slight. | .12    | 4.75                    | 1.15              | .0012    | .0082       | .0072      | .0010      | .16       | .0000       | .0002     | .1560            | 2.2       |

Odor of the first sample, none; of the second, faintly vegetable, becoming stronger on heating; of the third, faintly mouldy; of the last, faintly vegetable, becoming stronger and also musty on heating. — The first sample was collected from Tucker Brook,  $\frac{1}{4}$  mile above its junction with Manhan Brook; the second, from Tucker Brook, just above the junction; the third, from Manhan Brook,  $\frac{1}{4}$  mile above its junction with Tucker Brook; and the last, from Manhan Brook, just above the junction of the two brooks.

*Microscopical Examination.*

An insignificant number of organisms was found in each of these samples.

LOWELL.

*Chemical Examination of Water from the Merrimack River above Lowell, opposite the Intake of the Lowell Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1893.   |                     |             |                   |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 9888    | Jan. 17             | V. slight.  | V. slight.        | 0.35   | 3.80                            | 1.15                 | .0054    | .0156       | .0132      | .0024           | .23       | .0100          | .0001     | .4672            | 1.2       |
| 10012   | Feb. 14             | Distinct.   | Cons.             | 0.40   | 3.45                            | 1.40                 | .0012    | .0210       | .0166      | .0044           | .12       | .0090          | .0001     | .5235            | 1.8       |
| 10115   | Mar. 14             | Slight.     | Cons.,<br>earthy. | 0.40   | 3.25                            | 1.10                 | .0026    | .0178       | .0140      | .0038           | .19       | .0180          | .0000     | .4721            | 0.9       |
| 10261   | Apr. 18             | Slight.     | Cons.,<br>earthy. | 0.43   | 2.65                            | 1.05                 | .0004    | .0142       | .0110      | .0032           | .12       | .0050          | .0000     | .4526            | 0.8       |
| 10407   | May 16              | Decided.    | Cons.,<br>earthy. | 0.50   | 3.25                            | 1.10                 | .0004    | .0102       | .0088      | .0014           | .07       | .0050          | .0002     | .5548            | 0.8       |
| 10536   | June 20             | V. slight.  | Slight.           | 0.20   | 3.00                            | 0.95                 | .0014    | .0150       | .0106      | .0044           | .16       | .0070          | .0000     | .3718            | 1.1       |
| 10675   | July 18             | Slight.     | Slight.           | 0.10   | 3.80                            | 1.15                 | .0020    | .0170       | .0140      | .0030           | .18       | .0050          | .0002     | .2886            | 0.9       |
| 10869   | Aug. 22             | Slight.     | Slight.           | 0.18   | 3.70                            | 1.45                 | .0010    | .0128       | .0084      | .0044           | .20       | .0030          | .0002     | .3397            | 1.1       |
| 11045   | Sept. 19            | Slight.     | Slight.           | 0.40   | 3.55                            | 0.85                 | .0042    | .0156       | .0138      | .0018           | .18       | .0090          | .0001     | .4387            | 1.3       |
| 11209   | Oct. 17             | Slight.     | Slight.           | 0.30   | 3.25                            | 1.25                 | .0050    | .0114       | .0084      | .0030           | .17       | .0090          | .0000     | .3483            | 1.3       |
| 11366   | Nov. 21             | V. slight.  | Slight.           | 0.30   | 3.75                            | 1.15                 | .0032    | .0128       | .0106      | .0022           | .16       | .0100          | .0000     | .5124            | 1.1       |
| 11521   | Dec. 19             | V. slight.  | V. slight.        | 0.45   | 3.40                            | 1.50                 | .0044    | .0148       | .0144      | .0004           | .22       | .0100          | .0001     | .5548            | 1.3       |
| Av.     | .....               | .....       | .....             | 0.33   | 3.39                            | 1.18                 | .0026    | .0149       | .0120      | .0029           | .17       | .0083          | .0001     | .4437            | 1.1       |

Iron, .0133. Odor generally distinctly mouldy or musty, and frequently also vegetable. — The samples were collected from the river about one foot beneath the surface.

For a summary of analyses of previous years see "Merrimack River" in the chapter on Examination of Rivers, in a subsequent portion of this report.

*Microscopical Examination of Water from the Merrimack River above Lowell, opposite the Intake of the Lowell Water Works.*

[Number of organisms per cubic centimeter.]

|                     | 1893.               |       |       |       |       |       |       |       |       |       |       |       |
|---------------------|---------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                     | Jan.                | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
|                     | Day of examination, | 20    | 16    | 16    | 19    | 18    | 22    | 20    | 23    | 20    | 19    | 23    |
| Number of sample, . | 9888                | 10012 | 10115 | 10261 | 10407 | 10536 | 10675 | 10869 | 11045 | 11209 | 11366 | 11521 |
| PLANTS.             |                     |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . .     | 34                  | 2     | 12    | 16    | 41    | 214   | 944   | 152   | 91    | 106   | 16    | 4     |
| Asterionella, . .   | 1                   | 0     | 1     | 0     | 5     | 0     | 5     | 0     | 13    | 14    | 4     | 0     |
| Cyclotella, . .     | 0                   | 0     | 0     | pr.   | 0     | 0     | 28    | 0     | 0     | 1     | 0     | 1     |
| Fragilaria, . .     | 0                   | 0     | 2     | 0     | 7     | 0     | 165   | 0     | 0     | 14    | 0     | 0     |
| Melosira, . .       | 3                   | 0     | 4     | 4     | 22    | 0     | 12    | 0     | 0     | 0     | 6     | 0     |
| Navicula, . .       | 1                   | 0     | 1     | 3     | 0     | 1     | 1     | 0     | 0     | 0     | 2     | 0     |
| Pinnularia, . .     | 0                   | 0     | 0     | 1     | 0     | 0     | 1     | 0     | 4     | 0     | 0     | 0     |
| Synedra, . .        | 9                   | 1     | 4     | 4     | 7     | 200   | 332   | 140   | 48    | 76    | 4     | 3     |
| Tabellaria, . .     | 20                  | 1     | 0     | 4     | 0     | 13    | 400   | 12    | 26    | 1     | 0     | 0     |



## HUDSON.

*Microscopical Examination of Water from Gates Pond, Berlin.*

[Number of organisms per cubic centimeter.]

|                                 | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|---------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                 | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . .     | 8     | 14    | 14    | 17    | 14    | 13    | 19    | 16    | 11    | 11    | 16    | 18    |
| Number of sample, . . . .       | 13621 | 13800 | 13902 | 14150 | 14280 | 14466 | 14641 | 14843 | 15126 | 15349 | 15554 | 15748 |
| <b>PLANTS.</b>                  |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . .             | 0     | 1     | 0     | 109   | 47    | 6     | 3     | 21    | 2     | 48    | 315   | 40    |
| Asterionella, . . . .           | 0     | pr.   | 0     | 3     | 20    | 0     | 0     | 0     | 0     | 6     | 35    | 30    |
| Cyclotella, . . . .             | 0     | 1     | 0     | 0     | 0     | 1     | 1     | 4     | 1     | 0     | 0     | 0     |
| Fragilaria, . . . .             | 0     | 0     | 0     | 0     | 0     | 1     | 2     | 2     | 0     | 0     | 0     | 0     |
| Melosira, . . . .               | 0     | 0     | 0     | 51    | 0     | 0     | 0     | 4     | 0     | 34    | 236   | 0     |
| Navicula, . . . .               | 0     | 0     | 0     | 1     | 0     | pr.   | 0     | 1     | 0     | 4     | 2     | 0     |
| Synedra, . . . .                | 0     | 0     | 0     | 48    | 13    | 0     | 0     | 6     | 0     | 3     | 36    | 6     |
| Tabellaria, . . . .             | 0     | 0     | 0     | 6     | 14    | 4     | 0     | 4     | 1     | 1     | 3     | 4     |
| Cyanophyceæ, . . . .            | 0     | 0     | 0     | 0     | 0     | 189   | 85    | 196   | 52    | 72    | 4     | 0     |
| Anabaena, . . . .               | 0     | 0     | 0     | 0     | 0     | 118   | 0     | 0     | 0     | 0     | 0     | 0     |
| Merismopedia, . . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 50    | 0     | 0     | 0     | 0     | 0     |
| Microcystis, . . . .            | 0     | 0     | 0     | 0     | 0     | 71    | 35    | 196   | 52    | 72    | 4     | 0     |
| Algae, . . . .                  | 0     | pr.   | 0     | 2     | 15    | 9     | 463   | 109   | 8     | 28    | 29    | 0     |
| Arthrodesmus, . . . .           | 0     | 0     | 0     | 1     | 5     | 1     | 2     | 0     | 0     | 0     | 1     | 0     |
| Pediastrum, . . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 9     | 0     | 0     | 0     | 0     |
| Protococcus, . . . .            | 0     | pr.   | 0     | 1     | 4     | 7     | 440   | 76    | 0     | 8     | 8     | 0     |
| Raphidium, . . . .              | 0     | 0     | 0     | 0     | 0     | 1     | 21    | 18    | 7     | 19    | 20    | 0     |
| Staurastrum, . . . .            | 0     | 0     | 0     | 0     | 6     | 0     | 0     | 0     | 1     | 1     | 0     | 0     |
| Stauroneis, . . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 6     | 0     | 0     | 0     | 0     |
| <b>ANIMALS.</b>                 |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . . .              | 106   | 9,355 | 0     | 37    | 110   | 0     | 37    | 3     | 15    | 19    | 20    | 3     |
| Ceratium, . . . .               | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     |
| Codonella, . . . .              | 8     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     |
| Cryptomonas, . . . .            | 54    | 4,800 | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon, . . . .              | 40    | 300   | 0     | 23    | 0     | 0     | 34    | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, . . . .        | 0     | 4,200 | 0     | 12    | 104   | 0     | 0     | 0     | 2     | 1     | 17    | 1     |
| Euglena, . . . .                | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Mallomonas, . . . .             | 0     | 50    | 0     | 0     | 0     | 0     | 3     | 0     | 0     | 1     | 0     | 0     |
| Peridinium, . . . .             | 2     | 3     | 0     | 2     | 6     | 0     | 0     | 3     | 11    | 2     | 2     | 2     |
| Trachelomonas, . . . .          | 2     | pr.   | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 13    | 0     | 0     |
| Miscellaneous, Zoöglæa, . . . . | 0     | 0     | 0     | 0     | 52    | 0     | 0     | 24    | 0     | 100   | 7     | 0     |
| TOTAL, . . . .                  | 106   | 9,356 | 0     | 148   | 224   | 204   | 588   | 353   | 77    | 267   | 375   | 43    |

*Table showing Heights of Water in Gates Pond Each Month during 1895.*

[High-water mark is 14 feet.]

| DATE. — 1895.       | Feet. | DATE. — 1895.       | Feet. |
|---------------------|-------|---------------------|-------|
| Jan. 15, . . . . .  | 9.8   | July 15, . . . . .  | 9.5   |
| Feb. 15, . . . . .  | 9.2   | Aug. 15, . . . . .  | 9.1   |
| March 15, . . . . . | 9.2   | Sept. 15, . . . . . | 8.5   |
| April 15, . . . . . | 10.3  | Oct. 15, . . . . .  | 8.7   |
| May 15, . . . . .   | 10.5  | Nov. 15, . . . . .  | 9.3   |
| June 15, . . . . .  | 10.0  | Dec. 15, . . . . .  | 10.0  |

## LYNN.

## WATER SUPPLY OF LYNN.

The advice of the State Board of Health to the city of Lynn, with reference to increasing its water supply by taking water from the Saugus River and its tributaries, may be found on pages 25-28 of this report.

*Chemical Examination of Water from Breed's Pond, Lynn.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
|         | <b>1893.</b>        |             |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 9566    | Jan. 10             | V. slight.  | V. slight. | 0.85   | 4.35                            | 1.45                 | .0034    | .0194       | .0150      | .0044           | .62       | .0070          | .0001     | .6320            | 1.7       |
| 9996    | Feb. 9              | V. slight.  | V. slight. | 0.60   | 3.65                            | 1.55                 | .0134    | .0214       | .0170      | .0044           | .53       | .0090          | .0002     | .4526            | 1.5       |
| 10093   | Mar. 7              | V. slight.  | V. slight. | 0.50   | 3.70                            | 1.20                 | .0094    | .0144       | .0128      | .0016           | .63       | .0120          | .0002     | .4126            | 1.6       |
| 10218   | Apr. 6              | Slight.     | Slight.    | 0.60   | 3.50                            | 1.10                 | .0024    | .0176       | .0164      | .0012           | .50       | .0090          | .0004     | .4708            | 0.6       |
| 10367   | May 8               | V. slight.  | V. slight. | 0.48   | 3.35                            | 1.15                 | .0012    | .0150       | .0130      | .0020           | .45       | .0000          | .0000     | .5110            | 0.5       |
| 10485   | June 6              | Slight.     | Cons.      | 0.60   | 3.55                            | 1.55                 | .0022    | .0174       | .0142      | .0032           | .55       | .0030          | .0001     | .5402            | 0.8       |
| 10601   | July 5              | Slight.     | Slight.    | 0.48   | 3.55                            | 1.40                 | .0010    | .0262       | .0228      | .0034           | .53       | .0030          | .0001     | .5767            | 1.3       |
| 10747   | Aug. 8              | Distinct.   | Slight.    | 0.60   | 3.10                            | 1.10                 | .0006    | .0212       | .0182      | .0030           | .54       | .0000          | .0000     | .3996            | 0.9       |
| 10976   | Sept. 6             | Slight.     | Slight.    | 0.60   | 3.15                            | 1.25                 | .0006    | .0218       | .0182      | .0036           | .52       | .0000          | .0001     | .4800            | 0.8       |
| 11143   | Oct. 4              | Slight.     | Slight.    | 0.58   | 3.65                            | 2.00                 | .0014    | .0266       | .0220      | .0046           | .50       | .0050          | .0001     | .4697            | 0.9       |
| 11303   | Nov. 7              | Slight.     | Cons.      | 1.00   | 3.95                            | 1.60                 | .0030    | .0288       | .0250      | .0038           | .62       | .0070          | .0003     | .6120            | 0.6       |
| 11461   | Dec. 6              | Distinct.   | Slight.    | 0.90   | 3.85                            | 1.60                 | .0078    | .0270       | .0228      | .0042           | .56       | .0100          | .0001     | .5655            | 0.8       |
| Av.     | .....               | .....       | .....      | 0.65   | 3.61                            | 1.41                 | .0039    | .0214       | .0181      | .0033           | .55       | .0054          | .0001     | .5102            | 1.1       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 0.51 | 3.70 | 1.32 | .0006 | .0217 | -     | -     | .44 | .0024 | -     | -     | -   |
| - | 1888  | - | - | 0.48 | 3.71 | 1.42 | .0029 | .0227 | -     | -     | .45 | .0053 | .0001 | -     | -   |
| - | 1889  | - | - | 0.45 | 3.09 | 1.02 | .0007 | .0208 | .0165 | .0043 | .41 | .0035 | .0001 | -     | -   |
| - | 1890  | - | - | 0.42 | 3.62 | 1.51 | .0014 | .0196 | .0155 | .0041 | .41 | .0052 | .0001 | -     | 1.1 |
| - | 1891  | - | - | 0.35 | 3.35 | 1.37 | .0009 | .0156 | .0131 | .0025 | .40 | .0080 | .0001 | -     | 0.8 |
| - | 1892  | - | - | 0.43 | 3.65 | 1.38 | .0004 | .0220 | .0177 | .0043 | .49 | .0055 | .0000 | -     | 1.0 |
| - | 1893  | - | - | 0.65 | 3.61 | 1.41 | .0039 | .0214 | .0181 | .0033 | .55 | .0054 | .0001 | .5102 | 1.1 |

\* June to December.

NOTE to analyses of 1893; Iron, .0223. Odor, vegetable and occasionally also mouldy and unpleasant or grassy. — The samples were collected from the pond near the gate-house about one foot beneath the surface.

## LYNN.

*Microscopical Examination of Water from Breed's Pond, Lynn.*

[Number of organisms per cubic centimeter.]

|                                  | 1893. |      |       |       |       |       |       |       |       |       |       |       |
|----------------------------------|-------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                  | Jan.  | Feb. | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, .            | 12    | 11   | 8     | 8     | 10    | 8     | 7     | 9     | 8     | 6     | 10    | 8     |
| Number of sample, .              | 9866  | 9990 | 10093 | 10218 | 10367 | 10485 | 10601 | 10747 | 10976 | 11143 | 11303 | 11461 |
| <b>PLANTS.</b>                   |       |      |       |       |       |       |       |       |       |       |       |       |
| <b>Diatomaceæ,</b> . .           | 8     | 0    | 0     | 10    | 107   | 29    | 112   | 73    | 128   | 370   | 773   | 122   |
| Asterionella, . .                | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 36    | 4     | 93    | 120   |
| Melosira, . . .                  | 0     | 0    | 0     | 0     | 12    | 0     | 0     | 0     | 16    | 6     | 0     | 0     |
| Synedra, . . .                   | 0     | 0    | 0     | 5     | 58    | 0     | 4     | 1     | 0     | 0     | 0     | 0     |
| Tabellaria, . .                  | 8     | 0    | 0     | 5     | 37    | 29    | 108   | 72    | 76    | 380   | 680   | 2     |
| <b>Cyanophyceæ,</b> . .          | 0     | 0    | 0     | 0     | 1     | 30    | 0     | 113   | 23    | 130   | 24    | 0     |
| Anabena, . . .                   | 0     | 0    | 0     | 0     | 1     | 30    | 0     | 96    | 11    | 130   | 24    | 0     |
| Clathrocyttia, .                 | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 17    | 5     | 0     | 0     | 0     |
| Merismopedia, .                  | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 7     | 0     | 0     | 0     |
| <b>Algeæ,</b> . . . .            | 0     | 0    | 0     | 0     | 22    | 2     | 14    | 16    | 8     | 5     | 8     | 0     |
| Raphidium, . .                   | 0     | 0    | 0     | 0     | 0     | 2     | 0     | 10    | 8     | 0     | 8     | 0     |
| Scenedesmus, . .                 | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 5     | 0     | 0     |
| Staurostrum, . .                 | 0     | 0    | 0     | 0     | pr.   | 0     | 8     | 4     | 0     | 0     | 0     | 0     |
| Tetraspora, . .                  | 0     | 0    | 0     | 0     | 18    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Zoöspores, . .                   | 0     | 0    | 0     | 0     | 4     | pr.   | 6     | 0     | 0     | 0     | 0     | 0     |
| <b>Fungi, Glaucothrix,</b> .     | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 12    | 0     | 0     | 0     |
| <b>ANIMALS.</b>                  |       |      |       |       |       |       |       |       |       |       |       |       |
| <b>Rhizopoda,</b>                |       |      |       |       |       |       |       |       |       |       |       |       |
| Actinophrys, . .                 | 1     | 0    | 0     | 0     | 2     | 0     | 0     | 1     | 0     | 0     | 13    | 0     |
| <b>Infusoria,</b> . . .          | 1     | 0    | 1     | 0     | 89    | 13    | 8     | 30    | 25    | 62    | 20    | 42    |
| Dinobryon, . . .                 | 0     | 0    | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, .               | 0     | 0    | 0     | 0     | 84    | 13    | 3     | 22    | 24    | 0     | 20    | 25    |
| Glenodinium, . .                 | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 3     |
| Peridinium, . .                  | 1     | 0    | 1     | 0     | 2     | 0     | 5     | 8     | 1     | 60    | 0     | 14    |
| Trachelomonas, .                 | 0     | 0    | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 2     | 0     | 0     |
| <b>Vermes, Anurea,</b> . .       | 0     | 0    | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 1     |
| <b>Miscellaneous, Zoöglæa,</b> . | 0     | 0    | 0     | 6     | 14    | 64    | 52    | 320   | 76    | 38    | 10    | 2     |
| <b>TOTAL,</b> . . . .            | 10    | 0    | 1     | 16    | 235   | 140   | 186   | 553   | 272   | 605   | 848   | 167   |

## HYDE PARK AND MILTON.

*Chemical Examination of Water from the Neponset River at Hyde Park.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |               |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|------------------|---------------|--------|-------------------------|-------------------|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.       | Sediment.     | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |             |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                  |               |        |                         |                   |          | Total.      | Dissolved. | Sus-pended. |           |             |           |                  |           |
| 13655   | 1895. Jan. 14       | Distinct, milky. | Slight.       | 0.95   | 5.20                    | 1.95              | .0006    | .0236       | .0198      | .0038       | 0.71      | .0120       | .0000     | 0.7854           | 1.6       |
| 13834   | Feb. 18             | Decided.         | Cons., gray.  | 0.90   | 11.35                   | 3.00              | .0066    | .0350       | .0268      | .0082       | 1.86      | .0120       | .0002     | 1.1583           | 3.4       |
| 13992   | Mar. 18             | Distinct.        | Slight.       | 0.90   | 5.20                    | 1.95              | .0006    | .0204       | .0196      | .0008       | 0.57      | .0030       | .0000     | 0.8279           | 2.2       |
| 14148   | Apr. 15             | Slight.          | Slight.       | 1.20   | 5.20                    | 2.40              | .0014    | .0280       | .0244      | .0036       | 0.64      | .0000       | .0000     | 1.0744           | 2.1       |
| 14306   | May 15              | Distinct.        | Cons., brown. | 1.50   | 7.05                    | 2.90              | .0030    | .0420       | .0360      | .0060       | 0.66      | .0030       | .0002     | 1.3983           | 2.3       |
| 14487   | June 18             | Decided.         | Cons., rusty. | 1.10   | 13.65                   | 3.40              | .0238    | .0522       | .0398      | .0124       | 1.90      | .0030       | .0000     | 1.0418           | 5.6       |
| 14638   | July 22             | Decided.         | Heavy, rusty. | 0.90   | 10.40                   | 2.75              | .0328    | .0460       | .0356      | .0104       | 1.60      | .0000       | .0002     | 0.9000           | 4.0       |
| 14893   | Aug 20              | Distinct.        | Cons., rusty. | 0.73   | 9.25                    | 2.85              | .0752    | .0362       | .0312      | .0050       | 1.42      | .0000       | .0001     | 0.6708           | 3.1       |
| 15188   | Sept. 17            | Slight.          | Slight.       | 0.70   | 11.65                   | 2.50              | .0684    | .0512       | .0482      | .0030       | 2.54      | .0030       | .0002     | 0.9826           | 5.1       |
| 15370   | Oct. 15             | Slight.          | Cons.         | 1.10   | 8.30                    | 3.95              | .0004    | .0504       | .0426      | .0078       | 0.88      | .0120       | .0003     | 1.3533           | 2.5       |
| 15540   | Nov. 19             | Slight.          | Slight.       | 1.30   | 6.80                    | 3.00              | .0018    | .0282       | .0266      | .0016       | 0.71      | .0070       | .0001     | 1.3338           | 1.9       |
| 15759   | Dec. 17             | Slight.          | Slight.       | 1.15   | 6.75                    | 3.10              | .0022    | .0244       | .0232      | .0012       | 0.64      | .0220       | .0002     | 1.0202           | 1.8       |
| Av.     | .....               | .....            | .....         | 1.04   | 8.40                    | 2.81              | .0182    | .0365       | .0312      | .0053       | 1.18      | .0064       | .0001     | 1.0458           | 3.0       |

## Averages by Years.

|   |       |   |   |      |       |      |       |       |       |       |      |       |       |        |     |
|---|-------|---|---|------|-------|------|-------|-------|-------|-------|------|-------|-------|--------|-----|
| - | 1887* | - | - | 1.19 | 8.35  | 2.30 | .0053 | .0400 | -     | -     | 0.99 | .0080 | -     | -      | -   |
| - | 1888  | - | - | 1.02 | 6.77  | 2.27 | .0030 | .0324 | -     | -     | 0.83 | .0095 | .0002 | -      | -   |
| - | 1891† | - | - | 1.48 | 10.34 | 3.45 | .0190 | .0510 | .0413 | .0097 | 1.16 | .0065 | .0003 | -      | 3.3 |
| - | 1892‡ | - | - | 0.90 | 13.80 | 2.85 | .0260 | .0324 | .0286 | .0038 | 2.31 | .0090 | .0012 | -      | 4.4 |
| - | 1893  | - | - | 1.16 | 7.70  | 2.49 | .0151 | .0320 | .0254 | .0066 | 1.19 | .0154 | .0005 | 0.9548 | 2.4 |
| - | 1894  | - | - | 1.14 | 9.68  | 2.69 | .0112 | .0360 | .0277 | .0083 | 1.64 | .0062 | .0002 | 1.0003 | 3.0 |
| - | 1895  | - | - | 1.04 | 8.40  | 2.81 | .0182 | .0365 | .0312 | .0053 | 1.18 | .0064 | .0001 | 1.0458 | 3.0 |

\* June to December.

† August and September.

‡ July.

NOTE to analyses of 1895: Odor, generally decidedly vegetable and musty or disagreeable, and occasionally offensive.—The samples were collected from the river, opposite the works of the Hyde Park Water Company. The river is not used directly as a source of water supply.

## HYDE PARK AND MILTON.

*Microscopical Examination of Water from the Neponset River at Hyde Park.*

[Number of organisms per cubic centimeter.]

|                             | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|-----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                             | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .   | 15    | 20    | 19    | 17    | 16    | 19    | 28    | 22    | 18    | 17    | 21    | 20    |
| Number of sample, . . .     | 13658 | 13834 | 13992 | 14148 | 14306 | 14487 | 14658 | 14803 | 15188 | 15370 | 15580 | 15799 |
| <b>PLANTS.</b>              |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . .         | 7     | 2     | 7     | 67    | 85    | 21    | 4     | 28    | 2     | 88    | 4     | 1     |
| Asterionella, . . . .       | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 16    | 0     | 0     |
| Ceratoneis, . . . .         | 0     | 0     | 0     | 3     | 5     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Cyclotella, . . . .         | 0     | 1     | 0     | 0     | 17    | 12    | 0     | 7     | 0     | 6     | 0     | 0     |
| Diatoma, . . . .            | 1     | 0     | 0     | 1     | 1     | 0     | 0     | 1     | 0     | 6     | 0     | 0     |
| Fragilaria, . . . .         | 0     | 0     | 0     | 0     | 2     | 0     | 4     | 0     | 0     | 0     | 0     | 0     |
| Melosira, . . . .           | 0     | 0     | 0     | 4     | 12    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Navicula, . . . .           | 1     | 1     | 0     | 1     | 5     | 1     | 0     | 0     | 1     | 4     | 3     | 0     |
| Synedra, . . . .            | 3     | 0     | 6     | 46    | 36    | 8     | 0     | 20    | 1     | 56    | 1     | 1     |
| Tabellaria, . . . .         | 2     | 0     | 1     | 10    | 7     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Cyanophyceæ, Microcystis, . | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 2     | 0     | 2     | 0     | 0     |
| Algeæ, . . . .              | 0     | 0     | 1     | 2     | 15    | 2     | 14    | 50    | 0     | 12    | 0     | 0     |
| Gleocapsa, . . . .          | 0     | 0     | 0     | 0     | 4     | 0     | 0     | 12    | 0     | 0     | 0     | 0     |
| Protopoccus, . . . .        | 0     | 0     | 1     | 0     | 0     | 0     | 14    | 22    | 0     | 0     | 0     | 0     |
| Raphidium, . . . .          | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 8     | 0     | 0     |
| Scenedesmus, . . . .        | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 12    | 0     | 2     | 0     | 0     |
| Zoöspores, . . . .          | 0     | 0     | 0     | 2     | 9     | 0     | 0     | 4     | 0     | 2     | 0     | 0     |
| Fungi, Crenothrix, . . .    | 44    | 140   | 5     | 6     | 608   | 484   | 9,600 | 56    | 44    | 30    | 228   | 7     |
| <b>ANIMALS.</b>             |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . . .          | 2     | 0     | 3     | 12    | 9     | 0     | 14    | 44    | 1     | 8     | 0     | 0     |
| Dinobryon, . . . .          | 0     | 0     | 0     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, . . .      | 0     | 0     | 0     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Monas, . . . .              | 0     | 0     | 0     | 1     | 1     | 0     | 0     | 24    | 0     | 4     | 0     | 0     |
| Peridinium, . . . .         | 2     | 0     | 3     | 4     | 1     | 0     | 6     | 13    | 1     | 0     | 0     | 0     |
| Phacus, . . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     |
| Trachelomonas, . . . .      | 0     | 0     | 0     | 1     | 7     | 0     | 8     | 7     | 0     | 2     | 0     | 0     |
| Vermes, Rotifer, . . .      | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     |
| Miscellaneous, Zoöglæa, . . | 184   | 1,440 | 26    | 60    | 68    | 840   | 0     | 48    | 96    | 120   | 60    | 80    |
| TOTAL, . . . .              | 237   | 1,582 | 42    | 147   | 785   | 1,349 | 9,632 | 228   | 143   | 262   | 292   | 88    |

LYNN.

*Chemical Examination of Water from Walden Pond, Lynn.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|--------------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.         | Sediment.         | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                    |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1893.   |                     |                    |                   |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 9868    | Jan. 10             | Distinct.          | Heavy,            | 1.10   | 5.55                            | 3.15                 | .0006    | .0736       | .0434      | .0302           | .51       | .0150          | .0004     | 1.2880           | 1.6       |
| 9882    | Jan. 13             | Distinct.          | green,<br>Cons.   | 1.10   | -                               | -                    | -        | -           | -          | -               | -         | -              | -         | -                | -         |
| 9997    | Feb. 9              | Slight.            | Slight.           | 1.10   | 5.65                            | 2.90                 | .0376    | .0530       | .0484      | .0046           | .50       | .0090          | .0001     | .9964            | 1.8       |
| 10094   | Mar. 7              | Slight.            | V. slight.        | 1.35   | 4.50                            | 2.75                 | .0052    | .0178       | .0162      | .0016           | .50       | .0030          | .0001     | 1.1052           | 1.1       |
| 10154   | Mar. 22             | Distinct.          | Cons.             | 0.80   | 3.15                            | 1.55                 | .0076    | .0148       | .0144      | .0004           | .38       | .0000          | .0000     | .6408            | 0.9       |
| 10220   | Apr. 6              | Distinct.          | Slight.           | 0.90   | 3.10                            | 1.30                 | .0142    | .0380       | .0242      | .0144           | .38       | .0030          | .0003     | .5548            | 0.2       |
| 10369   | May 8               | Slight.            | Cons.             | 0.70   | 2.80                            | 1.25                 | .0012    | .0276       | .0202      | .0074           | .36       | .0050          | .0000     | .6094            | 0.2       |
| 10487   | June 6              | V. slight.         | Slight.           | 1.10   | 3.45                            | 1.95                 | .0110    | .0378       | .0238      | .0140           | .44       | .0100          | .0002     | .6935            | 0.2       |
| 10602   | July 5              | Decided,<br>green. | Cons.,<br>brown.  | 1.25   | 4.60                            | 2.45                 | .0060    | .0488       | .0294      | .0194           | .39       | .0030          | .0000     | .8322            | 0.5       |
| 10749   | Aug. 8              | Decided,<br>green. | Cons.,<br>green.  | 1.10   | 4.95                            | 3.00                 | .0000    | .0880       | .0374      | .0506           | .44       | .0000          | .0001     | .7252            | 0.5       |
| 10978   | Sept. 6             | Decided,<br>green. | Cons.,<br>rusty.  | 0.70   | 4.55                            | 2.45                 | .0000    | .0646       | .0338      | .0308           | .44       | .0050          | .0001     | .7320            | 0.9       |
| 11145   | Oct. 4              | Distinct.          | Cons.             | 0.50   | 4.75                            | 3.25                 | .0016    | .0508       | .0306      | .0202           | .44       | .0030          | .0000     | .6660            | 0.5       |
| 11305   | Nov. 7              | Distinct.          | Cons.,<br>green.  | 0.70   | 4.50                            | 2.55                 | .0000    | .0500       | .0408      | .0092           | .46       | .0030          | .0002     | .7760            | 0.5       |
| 11463   | Dec. 6              | Distinct.          | Slight,<br>green. | 0.70   | 4.40                            | 2.65                 | .0014    | .0456       | .0394      | .0062           | .48       | .0000          | .0000     | .7605            | 0.6       |
| Av.*    | .....               | .....              | .....             | 0.92   | 4.33                            | 2.40                 | .0006    | .0470       | .0309      | .0161           | .44       | .0047          | .0001     | .7954            | 0.7       |

*Averages of Analyses of Previous Years.*

|   |      |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1890 | - | - | 1.06 | 4.98 | 2.53 | .0292 | .0432 | .0351 | .0081 | .34 | .0057 | .0001 | -     | 1.1 |
| - | 1891 | - | - | 1.21 | 4.32 | 2.20 | .0058 | .0615 | .0403 | .0212 | .34 | .0091 | .0001 | -     | 0.7 |
| - | 1892 | - | - | 0.90 | 4.81 | 2.50 | .0094 | .0626 | .0383 | .0243 | .41 | .0116 | .0001 | -     | 0.6 |
| - | 1893 | - | - | 0.92 | 4.33 | 2.40 | .0006 | .0470 | .0309 | .0161 | .44 | .0047 | .0001 | .7954 | 0.7 |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average given at the bottom of the table.

NOTE to analyses of 1893; Iron, .0234. Odor, distinctly vegetable and generally also unpleasant; on heating, the odor is somewhat stronger. — The samples were collected from, the pond near the gate-house, one foot beneath the surface.

## LYNN.

*Microscopical Examination of Water from Walden Pond, Lynn.*

[Number of organisms per cubic centimeter.]

| 1892.                      |       |      |      |       |       |       |       |       |       |       |       |       |             |
|----------------------------|-------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------------|
|                            | Jan.  | Jan. | Feb. | Mar.  | Mar.  | Apr.  | May   | June  | July  | Aug.  | Sept. | Oct.  | Nov. Dec.   |
| Day of examination, .      | 12    | 17   | 11   | 8     | 24    | 8     | 10    | 8     | 7     | 9     | 8     | 6     | 10 8        |
| Number of sample, .        | 9869  | 9892 | 9997 | 10094 | 10154 | 10220 | 10369 | 10487 | 10602 | 10749 | 10978 | 11145 | 11305 11463 |
| <b>PLANTS.</b>             |       |      |      |       |       |       |       |       |       |       |       |       |             |
| Diatomaceæ, .              | 0     | 0    | 0    | 0     | 0     | 28    | 235   | 0     | 2     | 0     | 5     | 56    | 0 28        |
| Asterionella, .            | 0     | 0    | 0    | 0     | 0     | 0     | 128   | 0     | 2     | 0     | 0     | 29    | 0 24        |
| Melosira, .                | 0     | 0    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 16    | 0 0         |
| Synedra, .                 | 0     | 0    | 0    | 0     | 0     | 4     | 3     | 0     | 0     | 0     | 0     | 0     | 0 2         |
| Tabellaria, .              | 0     | 0    | 0    | 0     | 0     | 24    | 104   | 0     | 0     | 0     | 5     | 1     | 0 0         |
| Cyanophyceæ, .             | 3     | 0    | 5    | 1     | 8     | 6     | 0     | 56    | 600   | 460   | 380   | 146   | 0 0         |
| Anabæna, .                 | 0     | 0    | 0    | 0     | 0     | 3     | 0     | 42    | 36    | 420   | 0     | 64    | 0 0         |
| Anabæna spores, .          | 0     | 0    | 0    | 0     | 0     | 0     | 0     | 0     | 44    | 0     | 0     | 0     | 0 0         |
| Clathrocystis, .           | 3     | 0    | 5    | 1     | 8     | 3     | 0     | 14    | 520   | 70    | 380   | 82    | 0 0         |
| Algæ, .                    | 2     | 0    | 0    | 0     | 0     | 81    | 28    | 144   | 4     | 6     | 7     | 2     | 0 0         |
| Chlorococcus, .            | 0     | 0    | 0    | 0     | 0     | 0     | pr.   | 74    | 0     | 0     | 0     | 0     | 0 0         |
| Closterium, .              | 2     | 0    | 0    | 0     | 0     | 7     | 1     | 24    | 1     | 0     | 0     | 0     | 0 0         |
| Pediastrum, .              | 0     | 0    | 0    | 0     | 0     | 0     | 1     | 0     | 0     | 6     | 1     | 0     | 0 0         |
| Staurastrum, .             | 0     | 0    | 0    | 0     | 0     | pr.   | 6     | 46    | 3     | 0     | 6     | 2     | 0 0         |
| Zoöspores, .               | 0     | 0    | 0    | 0     | 0     | 74    | 20    | 0     | 0     | 0     | 0     | 0     | 0 0         |
| Fungi, Crenothrix, .       | 0     | 0    | 0    | 0     | 0     | 7     | 2     | 1     | 0     | 0     | 3     | 6     | 240 1       |
| <b>ANIMALS.</b>            |       |      |      |       |       |       |       |       |       |       |       |       |             |
| Infusoria, .               | 1,113 | 0    | 9    | 6     | 0     | 47    | 29    | 0     | 0     | 20    | 0     | 7     | 0 16        |
| Bursaria, .                | 0     | *    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0 1         |
| Cryptomonas, .             | 1,084 | 0    | 0    | 6     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0 0         |
| Dinobryon, .               | 0     | 0    | 0    | 0     | 0     | 1     | 1     | 0     | 0     | 0     | 0     | 0     | 0 0         |
| Dinobryon cases, .         | 0     | 0    | 0    | 0     | 0     | 0     | 22    | 0     | 0     | 0     | 0     | 0     | 0 13        |
| Disintegrated Infusoria, . | 0     | 0    | 0    | 0     | 0     | 14    | 0     | 0     | 0     | 0     | 0     | 0     | 0 0         |
| Euglena, .                 | 0     | 0    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0 2         |
| Peridinium, .              | 28    | 0    | 9    | 0     | 0     | 80    | 6     | 0     | 0     | 20    | 0     | 1     | 0 0         |
| Trachelomonas, .           | 1     | 0    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 6     | 0 0         |
| Vermes, .                  | 1     | 0    | 0    | 3     | 0     | 1     | 0     | pr.   | 0     | 0     | 0     | 0     | 0 0         |
| Anurea, .                  | 0     | 0    | 0    | 2     | 0     | 0     | 0     | pr.   | 0     | 0     | 0     | 0     | 0 0         |
| Polyarthra, .              | 1     | 0    | 0    | 1     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0 0         |
| Crustacea, Cyclops, .      | .08   | 0    | .04  | 0     | 0     | 0     | 0     | .03   | 0     | 0     | 0     | 0     | 0 0         |
| Miscellaneous, Zoöglæa, .  | 0     | 0    | 0    | 0     | 0     | 830   | 34    | 112   | 44    | 15    | 48    | 166   | 32 0        |
| TOTAL, .                   | 1,119 | *    | 14   | 10    | 8     | 1,100 | 328   | 313   | 650   | 530   | 443   | 383   | 272 43      |

\* Bursaria extremely abundant.

LYNN.

*Chemical Examination of Water from Glen Lewis Pond, Lynn.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. |     | Hardness. |
|---------|---------------------|---------------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----|-----------|
|         |                     | Turbidity.          | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |     |           |
|         |                     |                     |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |     |           |
| 9867    | 1893.<br>Jan. 10    | Distinct.           | Heavy,<br>green.  | 0.70   | 4.10                            | 2.00                 | .0052    | .0740       | .0360      | .0380           | .51       | .0030          | .0002     | .8160            | 1.8 |           |
| 10219   | Apr. 6              | Distinct,<br>green. | Slight.           | 0.18   | 2.10                            | 0.65                 | .0032    | .0202       | .0152      | .0050           | .34       | .0030          | .0003     | .2701            | 0.6 |           |
| 10368   | May 8               | Slight.             | Slight.           | 0.38   | 2.25                            | 0.70                 | .0046    | .0186       | .0168      | .0018           | .32       | .0070          | .0000     | .3978            | 0.2 |           |
| 10486   | June 6              | Decided,<br>green.  | Cons.,<br>green.  | 1.10   | 4.15                            | 2.35                 | .0476    | .1066       | .0532      | .1434           | .41       | .0090          | .0002     | .7409            | 0.2 |           |
| 10644   | July 11             | Slight,<br>green.   | Slight.           | 0.80   | 3.85                            | 2.35                 | .0386    | .0538       | .0408      | .0130           | .42       | .0070          | .0002     | .5475            | 0.5 |           |
| 10748   | Aug. 3              | Decided,<br>green.  | Heavy,<br>yellow. | 0.75   | 4.50                            | 2.65                 | .0002    | .0636       | .0292      | .0344           | .42       | .0000          | .0001     | .5402            | 0.5 |           |
| 10979   | Sept. 6             | Decided.            | Heavy,<br>yellow. | -      | -                               | -                    | -        | -           | -          | -               | -         | -              | -         | -                | -   |           |
| 11066   | Sept. 20            | Decided,<br>green.  | Heavy,<br>yellow. | 0.50   | 4.00                            | 2.60                 | .0000    | .0804       | .0272      | .0332           | .44       | .0050          | .0000     | .6314            | 0.9 |           |
| 11144   | Oct. 4              | Decided.            | Cons.,<br>green.  | 0.40   | 4.00                            | 2.90                 | .0000    | .0490       | .0326      | .0164           | .42       | .0030          | .0000     | .6006            | 0.5 |           |
| 11304   | Nov. 7              | Slight.             | Cons.             | 0.85   | 4.10                            | 2.60                 | .0118    | .0398       | .0336      | .0062           | .46       | .0030          | .0003     | .7080            | 0.2 |           |
| 11462   | Dec. 6              | Decided,<br>green.  | Cons.,<br>green.  | 0.70   | 4.45                            | 2.60                 | .0010    | .1532       | .0444      | .1088           | .44       | .0000          | .0000     | .7956            | 0.3 |           |
| Av.     | .....               | .....               | .....             | 0.64   | 3.81                            | 2.14                 | .0112    | .0729       | .0329      | .0400           | .42       | .0040          | .0002     | .6048            | 0.6 |           |

*Averages of Analyses of Previous Years.*

|   |      |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1890 | - | - | 0.76 | 4.84 | 2.21 | .0412 | .0445 | .0327 | .0118 | .36 | .0063 | .0001 | -     | 1.0 |
| - | 1891 | - | - | 0.63 | 3.90 | 1.75 | .0328 | .0484 | .0324 | .0160 | .34 | .0124 | .0002 | -     | 0.6 |
| - | 1892 | - | - | 0.62 | 3.95 | 1.95 | .0127 | .0475 | .0332 | .0143 | .40 | .0193 | .0002 | -     | 0.6 |
| - | 1893 | - | - | 0.64 | 3.81 | 2.14 | .0112 | .0729 | .0329 | .0400 | .42 | .0040 | .0002 | .6048 | 0.6 |

NOTE to analyses of 1893; Iron, .0169. Odor, generally distinctly vegetable and frequently unpleasant; on heating, the odor is much stronger and is sometimes very disagreeable.—The samples were collected from the pond near the gate-house, one foot beneath the surface.



## IPSWICH.

*Chemical Examination of Water from a Spring in Ipswich.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Alb.-minhold. |           | Nitrates.   | Nitrites. |                  |           |       |
| 14371   | 1895.<br>May 27     | None.       | None.     | .00    | 4.25                    | .0000    | .0006         | .94       | .0550       | .0000     | .0228            | 2.7       | .0000 |
| 14726   | July 29             | V. slight   | Slight.   | .03    | 6.55                    | .0000    | .0014         | .94       | .0700       | .0000     | .0269            | 3.5       | .0000 |

Odor, none. — The samples were collected from a spring, located very near Dow's Brook, about 500 feet above the upper end of the Dow's Brook storage reservoir.

*Microscopical Examination.*

No. 14371. Diatomaceæ, *Meridion*, 6.

No. 14726. No organisms.

## WATER SUPPLY OF KINGSTON.

The advice of the State Board of Health to the town of Kingston with reference to the use of lead pipes in the distribution of the water supplied to the town may be found on pages 30 to 32 of this volume.

*Chemical Examination of Water from a Faucet supplied from the Kingston Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Alb.-minhold. |           | Nitrates.   | Nitrites. |                  |           |       |
| 14763   | 1895.<br>Aug. 5     | None.       | V. slight. | .02    | 5.10                    | .0008    | .0016         | .76       | .0730       | .0019     | .0624            | 1.8       | .0050 |

Odor, very faintly vegetable.

*Microscopical Examination.*

Fungi, *Crenothrix*, 3.

## WATER SUPPLY OF LAWRENCE.

The following tables contain analyses of the unfiltered Merrimack River water, and of the filtered water at the pumping station and at the distributing reservoir. The results of more extended chemical and biological examinations of the water before and after filtration through the sand filter may be found in a subsequent portion of this report.

## LYNN.

*Table showing Depth of Water in Feet in the Ponds and Storage Reservoirs of the Lynn Water Works on the Dates when Samples of Water were collected for Analysis during the Year 1893.*

|                    | Breed's Pond.<br>High Water,<br>*21.50 Feet. | Birch Pond.<br>High Water,<br>*21.50 Feet. | Walden Pond.<br>High Water,<br>17.00 Feet. | Glen Lewis Pond.<br>High Water,<br>17.00 Feet. |
|--------------------|----------------------------------------------|--------------------------------------------|--------------------------------------------|------------------------------------------------|
| Jan. 10, . . . . . | 11.96                                        | 7.54                                       | 14.50                                      | 8.54                                           |
| Feb. 9, . . . . .  | 12.75 *                                      | 8.00                                       | 12.83                                      | 6.37                                           |
| Mar. 7, . . . . .  | 15.13                                        | 9.67                                       | 12.88                                      | 6.40                                           |
| April 6, . . . . . | 20.25                                        | 17.08                                      | 14.50                                      | 10.67                                          |
| May 8, . . . . .   | 21.75                                        | 22.50                                      | 16.17                                      | 15.17                                          |
| June 6, . . . . .  | 21.08                                        | 22.58                                      | 16.83                                      | 17.33                                          |
| July 5, . . . . .  | 19.83                                        | 19.71                                      | 16.67                                      | 17.25                                          |
| Aug. 8, . . . . .  | 17.75                                        | 15.58                                      | 16.25                                      | 17.25                                          |
| Sept. 6, . . . . . | 16.71                                        | 11.88                                      | 16.00                                      | 17.13                                          |
| Oct. 4, . . . . .  | 14.50                                        | 8.92                                       | 16.58                                      | 17.00                                          |
| Nov. 7, . . . . .  | 10.50                                        | 7.00                                       | 15.50                                      | 17.06                                          |
| Dec. 6, . . . . .  | 10.67                                        | 5.67                                       | 16.92                                      | 11.13                                          |

\* The water in these ponds is sometimes raised somewhat above ordinary high water in the latter part of the spring in order to increase the storage.

## WATER SUPPLY OF MALDEN, MEDFORD AND MELROSE.

On Feb. 9, 1893, when Spot Pond had reached a much lower level than ever before, the State Board of Health addressed a communication to the Water Boards of Malden, Medford and Melrose, urging the necessity of taking immediate measures for increasing the amount of water in the pond, and giving estimates of the probable condition of the pond on Jan. 1, 1894, under minimum, average and maximum conditions of rainfall during the remaining eleven months of the year.

The estimates of the amount of water which would enter the pond were based upon the yield per square mile of watershed, as deduced from measurements of the flow from the Sudbury River watershed during the past eighteen years, and the influence of the evaporation from the surface of the pond was also included. The draft from the pond was reckoned at 600,000 gallons per day for each community, which was about the rate at which water was being drawn from the pond a few months before. It was urged, however, in the communication, that this draft from the pond

**MALDEN, MEDFORD AND MELROSE.**

should be reduced by taking as much water as possible from supplementary sources.

It is gratifying to note that at the end of the year the quantity drawn from the pond was 119,000,000 gallons (equivalent to a depth of about 2.5 feet on the pond) less than it would have been if each of the three communities had continued to draw at the rate of 600,000 gallons per day; the diminished draft being due in part to a restriction of use and waste, but still more to the amount of water supplied from supplementary sources throughout the whole year at Malden, and during the latter part of the year at Medford and Melrose.

The yield of the Sudbury River watershed during the eleven months from Feb. 1, 1893, to the end of the year was very nearly the same as the average for those months during the preceding eighteen years, and with average conditions the prediction contained in the communication indicated that the quantity of water in the pond would be increased 46,000,000 gallons on Jan. 1, 1894, upon the assumption that 600,000 gallons per day would be drawn by each community. To this quantity should be added the 119,000,000 gallons due to the smaller draft from the pond, making 165,000,000 gallons as the increased amount that should be in the pond on this date, according to the prediction.

By consulting the records of the height of the pond, it was found that it contained 184,000,000 gallons more on Jan. 1, 1894, than on Feb. 1, 1893, which showed a difference between the predicted yield in an average year and the actual yield of only 19,000,000 gallons; by taking into account the slight variation in the yield of the Sudbury River during these eleven months from the yield during the same months in an average year a still closer agreement was found. This is a further confirmation of what has already been well established, namely, that the capacity of this source may properly be reckoned upon the basis of the size of its watershed, assuming that the flow from each square mile is the same as from the watershed of Sudbury River.

## MALDEN, MEDFORD AND MELROSE.

*Chemical Examination of Water from Spot Pond, Stoneham.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|------------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.       | Sediment.       | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                  |                 |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 9850    | 1893.<br>Jan. 3     | Slight, clayey.  | Slight.         | 0.10   | 4.90                    | 1.40              | .0114    | .0178       | .0102      | .0016      | .52       | .0150       | .0001     | .2320            | 2.6       |
| 9982    | Feb. 7              | Distinct.        | Slight.         | 0.48   | 4.50                    | 1.35              | .0210    | .0142       | .0126      | .0016      | .36       | .0100       | .0005     | .2044            | 1.9       |
| 10083   | Mar. 6              | Distinct.        | V. slight.      | 0.70   | 7.05                    | 2.05              | .0210    | .0188       | .0164      | .0024      | .58       | .0200       | .0002     | .5688            | 3.0       |
| 10214   | Apr. 4              | Distinct.        | Cons.           | 0.35   | 5.45                    | 1.35              | .0140    | .0176       | .0152      | .0024      | .46       | .0300       | .0010     | .3504            | 2.5       |
| 10354   | May 2               | Slight.          | Slight.         | 0.38   | 5.80                    | 1.65              | .0072    | .0186       | .0150      | .0036      | .44       | .0150       | .0006     | .3321            | 2.2       |
| 10477   | June 5              | Distinct.        | Slight, brown.  | 0.35   | 5.05                    | 1.95              | .0052    | .0232       | .0180      | .0052      | .49       | .0100       | .0003     | .5025            | 1.9       |
| 10611   | July 5              | Decided, green.  | Slight, yellow. | 0.15   | 5.85                    | 1.85              | .0000    | .0192       | .0134      | .0058      | .50       | .0000       | .0000     | .3796            | 2.3       |
| 10742   | Aug. 7              | Decided, green.  | Cons.           | 0.15   | 5.75                    | 1.70              | .0000    | .0228       | .0158      | .0070      | .49       | .0030       | .0000     | .3034            | 3.5       |
| 10972   | Sept. 5             | Distinct, green. | Slight, brown.  | 0.18   | 6.00                    | 1.90              | .0012    | .0278       | .0212      | .0066      | .54       | .0000       | .0000     | .4240            | 2.2       |
| 11148   | Oct. 4              | Slight.          | Cons., dark.    | 0.18   | 6.20                    | 2.20              | .0076    | .0214       | .0198      | .0016      | .52       | .0030       | .0002     | .3234            | 2.3       |
| 11458   | Dec. 5              | Slight.          | Slight, dark.   | 0.13   | 6.15                    | 1.40              | .0048    | .0158       | .0150      | .0008      | .51       | .0100       | .0000     | .2145            | 2.2       |
| Av.     | .....               | .....            | .....           | 0.29   | 5.70                    | 1.71              | .0085    | .0197       | .0162      | .0035      | .49       | .0105       | .0003     | .3486            | 2.4       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 0.25 | 4.33 | 1.24 | .0004 | .0207 | -     | -     | .46 | .0025 | -     | -     | -   |
| - | 1888  | - | - | 0.22 | 3.98 | 1.24 | .0007 | .0225 | -     | -     | .44 | .0054 | .0001 | -     | -   |
| - | 1889  | - | - | 0.26 | 3.54 | 1.17 | .0017 | .0236 | .0198 | .0038 | .44 | .0053 | .0002 | -     | -   |
| - | 1890  | - | - | 0.24 | 3.96 | 1.24 | .0019 | .0220 | .0180 | .0040 | .42 | .0069 | .0001 | -     | 1.7 |
| - | 1891  | - | - | 0.21 | 3.70 | 1.27 | .0008 | .0183 | .0161 | .0022 | .43 | .0082 | .0001 | -     | 1.4 |
| - | 1892  | - | - | 0.17 | 4.28 | 1.30 | .0035 | .0198 | .0157 | .0041 | .50 | .0081 | .0001 | -     | 1.7 |
| - | 1893  | - | - | 0.29 | 5.70 | 1.71 | .0085 | .0197 | .0102 | .0035 | .49 | .0105 | .0003 | .3486 | 2.4 |

\* May to December.

NOTE to analyses of 1893; Iron, .0260. Odor, faintly vegetable and occasionally unpleasant; on heating, the odor is generally stronger; in July it was oily, in August and September, fishy, and in other months frequently grassy or mouldy. The samples were collected either from a faucet in the pumping station of the Malden Water Works or from the pond near by.

The averages of analyses for the years 1892 and 1893 when compared with the averages of previous years indicate a change in the character of the water, which is doubtless due to the fact that during these two years the surface of the water in the pond remained very much below high water mark.

## MALDEN, MEDFORD AND MELROSE.

*Microscopical Examination of Water from Spot Pond, Stoneham.*

[Number of organisms per cubic centimeter.]

|                                 | 1893. |      |       |       |       |       |       |       |       |       |       |  |
|---------------------------------|-------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--|
|                                 | Jan.  | Feb. | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Dec.  |  |
| Day of examination, . . . .     | 5     | 9    | 8     | 8     | 5     | 6     | 8     | 9     | 8     | 7     | 8     |  |
| Number of sample, . . . .       | 9850  | 9082 | 10083 | 10214 | 10354 | 10477 | 10611 | 10742 | 10972 | 11148 | 11458 |  |
| PLANTS.                         |       |      |       |       |       |       |       |       |       |       |       |  |
| Diatomaceæ, . . . .             | 62    | 3    | 1     | 28    | 416   | 782   | 312   | 315   | 106   | 161   | 21    |  |
| Asterionella, . . . .           | 3     | 0    | 0     | 1     | 9     | 0     | 0     | 0     | 0     | 3     | 13    |  |
| Cyclotella, . . . .             | 3     | 0    | 0     | 5     | 1     | 640   | 140   | 40    | 28    | 0     | 6     |  |
| Fragilaria, . . . .             | 0     | 0    | 0     | 2     | 10    | 0     | 0     | 0     | 0     | 0     | 0     |  |
| Melosira, . . . .               | 2     | 0    | 0     | 6     | 192   | 40    | 32    | 39    | 71    | 130   | 0     |  |
| Synedra, . . . .                | 0     | 1    | pr.   | 10    | 60    | 0     | 36    | 172   | 3     | 8     | 0     |  |
| Tabellaria, . . . .             | 54    | 2    | 1     | 4     | 154   | 112   | 104   | 64    | 4     | 20    | 2     |  |
| Cyanophyceæ, Anabaena, . . . .  | 0     | 0    | 0     | 0     | 0     | 10    | 132   | 208   | 15    | 0     | 0     |  |
| Algæ, . . . .                   | 2,059 | 0    | 0     | 0     | 481   | 247   | 6     | 23    | 30    | 8     | 0     |  |
| Chlorococcus, . . . .           | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 8     | 0     |  |
| Closterium, . . . .             | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 1     | 20    | 0     | 0     |  |
| Protococcus, . . . .            | 2,056 | 0    | 0     | 0     | 480   | 244   | 0     | 6     | 0     | 0     | 0     |  |
| Raphidium, . . . .              | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 7     | 0     | 0     | 0     |  |
| Staurostrum, . . . .            | 3     | 0    | 0     | 0     | 1     | 3     | 6     | 9     | 10    | pr.   | 0     |  |
| ANIMALS.                        |       |      |       |       |       |       |       |       |       |       |       |  |
| Rhizopoda, Actinophrys, . . . . | 3     | 0    | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 13    |  |
| Infusoria, . . . .              | 4     | pr.  | 1     | 68    | 67    | 12    | 4     | 77    | 71    | 20    | 1     |  |
| Dinobryon, . . . .              | 0     | 0    | 0     | 0     | 2     | 3     | 0     | 0     | 0     | 0     | 0     |  |
| Dinobryon cases, . . . .        | 0     | 0    | 0     | 0     | 64    | 5     | 0     | 0     | 64    | 20    | 0     |  |
| Peridinium, . . . .             | 4     | pr.  | 0     | 0     | 0     | 0     | 4     | 76    | 6     | 0     | 1     |  |
| Synura, . . . .                 | 0     | 0    | 0     | 60    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |  |
| Trachelomonas, . . . .          | 0     | 0    | 1     | 8     | 1     | 4     | 0     | 1     | 1     | pr.   | 0     |  |
| Miscellaneous, Zoöglæa, . . . . | 2     | 102  | 78    | 140   | 26    | 19    | 244   | 420   | 56    | 56    | 40    |  |
| TOTAL, . . . .                  | 2,130 | 105  | 80    | 236   | 990   | 1,080 | 698   | 1,044 | 278   | 245   | 75    |  |

Table showing Heights of Water in Spot Pond on the Dates when Samples of Water were collected for Analysis.

| DATE.              | Distance below High Water Mark. | DATE.              | Distance below High Water Mark. |
|--------------------|---------------------------------|--------------------|---------------------------------|
| <b>1893.</b>       | <b>Feet.</b>                    | <b>1893.</b>       | <b>Feet.</b>                    |
| Jan. 3, . . . . .  | 10.81                           | July 5, . . . . .  | 4.56                            |
| Feb. 8, . . . . .  | 11.42                           | Aug. 7, . . . . .  | 5.87                            |
| Mar. 6, . . . . .  | 10.71                           | Sept. 5, . . . . . | 6.75                            |
| April 4, . . . . . | 6.81                            | Oct. 4, . . . . .  | 8.04                            |
| May 2, . . . . .   | 5.56                            | Dec. 5, . . . . .  | 8.75                            |
| June 5, . . . . .  | 3.67                            |                    |                                 |

## MALDEN.

## WATER SUPPLY OF MALDEN.

*Chemical Examination of Water from Tubular Wells at Webster Park (Eaton's Meadows), Malden.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1893.</b>        |             |            |        |                         |          |             |           |             |           |                  |           |       |
| 9849    | Jan. 3              | None.       | V. slight. | 0.0    | 22.35                   | .0000    | .0015       | 2.20      | .4750       | .0000     | .0000            | 12.4      | .0080 |
| 9983    | Feb. 7              | None.       | None.      | 0.0    | 23.90                   | .0000    | .0016       | 2.52      | .5000       | .0000     | .0285            | 13.4      | .0000 |
| 10084   | Mar. 6              | None.       | None.      | 0.0    | 24.70                   | .0000    | .0002       | 2.68      | .4500       | .0000     | .0014            | 11.5      | .0000 |
| 10215   | Apr. 4              | None.       | None.      | 0.0    | 25.55                   | .0000    | .0012       | 2.40      | .4800       | .0001     | .0058            | 11.8      | .0000 |
| 10355   | May 2               | None.       | None.      | 0.0    | 24.50                   | .0002    | .0032       | 2.35      | .5000       | .0001     | .0365            | 9.0       | .0100 |
| 10478   | June 5              | None.       | None.      | 0.0    | 24.60                   | .0000    | .0002       | 2.83      | .4750       | .0000     | .0337            | 10.7      | .0050 |
| 10612   | July 5              | None.       | None.      | 0.0    | 25.20                   | .0000    | .0005       | 2.62      | .5000       | .0000     | .0292            | 10.9      | .0000 |
| 10743   | Aug. 7              | None.       | None.      | 0.0    | 23.00                   | .0000    | .0016       | 2.56      | .5000       | .0000     | .0000            | 10.0      | .0100 |
| 10973   | Sept. 5             | None.       | None.      | 0.0    | 22.70                   | .0010    | .0000       | 2.33      | .5000       | .0001     | .0240            | 10.4      | .0000 |
| 11149   | Oct. 4              | None.       | None.      | 0.0    | 22.60                   | .0000    | .0002       | 2.37      | .5000       | .0000     | .0077            | 10.4      | .0000 |
| 11459   | Dec. 5              | None.       | Slight.    | 0.0    | 21.80                   | .0000    | .0018       | 2.45      | .4250       | .0000     | .0195            | 11.2      | .1000 |
| Av.     | .....               | .....       | .....      | 0.0    | 23.72                   | .0001    | .0011       | 2.48      | .4823       | .0000     | .0186            | 11.1      | .0121 |

## Averages of Analyses of Previous Years.

|   |       |   |   |     |       |       |       |      |       |       |       |      |       |
|---|-------|---|---|-----|-------|-------|-------|------|-------|-------|-------|------|-------|
| - | 1887* | - | - | 0.0 | 17.03 | .0000 | .0008 | 2.20 | .4050 | -     | -     | -    | -     |
| - | 1888  | - | - | 0.0 | 17.45 | .0000 | .0003 | 2.30 | .5081 | -     | -     | -    | -     |
| - | 1889† | - | - | 0.0 | 16.95 | .0001 | .0031 | 1.75 | .5500 | .0001 | -     | 7.3  | -     |
| - | 1890  | - | - | 0.0 | 18.19 | .0002 | .0014 | 2.30 | .4904 | .0001 | -     | 8.0  | -     |
| - | 1891  | - | - | 0.0 | 20.83 | .0001 | .0007 | 2.23 | .5146 | .0001 | -     | 9.6  | -     |
| - | 1892  | - | - | 0.0 | 23.00 | .0000 | .0005 | 2.36 | .5129 | .0000 | -     | 11.4 | -     |
| - | 1893  | - | - | 0.0 | 23.72 | .0001 | .0011 | 2.48 | .4823 | .0000 | .0186 | 11.1 | .0121 |

\* Three samples in November and December.

† June and October.

NOTE to analyses of 1893; Odor, none. — The samples were collected from a faucet at the pumping station, while pumping, with the exception of No. 10612, which was collected from a drinking fountain.

**MALDEN.***Microscopical Examination of Water from Tubular Wells at Webster Park (Eaton's Meadows), Malden.*

[Number of organisms per cubic centimeter.]

| 1893.                       |      |      |       |       |       |       |       |       |       |       |       |
|-----------------------------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                             | Jan. | Feb. | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Dec.  |
| Day of examination, . . .   | 5    | 9    | 8     | 8     | 5     | 6     | 8     | 9     | 7     | 7     | 8     |
| Number of sample, . . .     | 9849 | 9983 | 10084 | 10215 | 10355 | 10478 | 10612 | 10743 | 10973 | 11149 | 11459 |
| <b>PLANTS.</b>              |      |      |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .           | 0    | 0    | 0     | 1     | 24    | pr.   | 0     | 32    | 0     | 5     | 0     |
| Asterionella, . . .         | 0    | 0    | 0     | 0     | 6     | 0     | 0     | 0     | 0     | pr.   | 0     |
| Melosira, . . .             | 0    | 0    | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 5     | 0     |
| Synedra, . . .              | 0    | 0    | 0     | 0     | 18    | pr.   | 0     | 32    | 0     | pr.   | 0     |
| Miscellaneous, Zoöglæa, . . | 0    | 0    | 1     | 0     | 0     | 1     | 0     | 0     | 0     | 22    | 0     |
| TOTAL, . . .                | 0    | 0    | 1     | 1     | 24    | 1     | 0     | 32    | 0     | 27    | 0     |

**WATER SUPPLY OF MANCHESTER.***Chemical Examination of Water from the Well of the Manchester Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitriles. |                  |           |       |
| 10042   | 1893.<br>Feb. 25    | None.       | V. slight. | 0.0    | 9.35                    | .0000    | .0004       | 1.68      | .1000       | .0000     | .0106            | 3.6       | .0000 |
| 10459   | May 31              | V. slight.  | V. slight. | 0.0    | 11.10                   | .0000    | .0002       | 1.86      | .1000       | .0000     | .0337            | 3.4       | .0000 |
| 11080   | Sept. 22            | None.       | None.      | 0.0    | 9.40                    | .0000    | .0002       | 1.74      | .0900       | .0000     | .0492            | 3.9       | .0035 |
| 11380   | Nov. 23             | None.       | None.      | 0.0    | 8.70                    | .0000    | .0000       | 1.49      | .1000       | .0000     | .0545            | 3.2       | .0300 |
| Av.     | .....               | .....       | .....      | 0.0    | 9.64                    | .0000    | .0002       | 1.69      | .0975       | .0000     | .0370            | 3.5       | .0006 |

Odor, none. — The samples were collected from the well.

*Microscopical Examination.*

No. 10042. Miscellaneous, Zoöglæa, 2.

Nos. 10459 and 11380. Miscellaneous, Zoöglæa, 1 in each.

No. 11080. No organisms.

## MARBLEHEAD.

## WATER SUPPLY OF MARBLEHEAD.

The works from which the water supply of Marblehead is drawn were enlarged in 1892 by the addition of a group of five tubular wells situated about 800 feet south-east of the pumping station. The depth of the wells varies from 25 to 53 feet. From April until November, 1893, water from these wells was pumped, by means of an auxiliary pump, into the large collecting well near the pumping station. In 1893 a further addition to the works for obtaining a supply of ground water was made by the construction of a small collecting well about eight feet in depth, near a small pond, and a short distance from the tubular wells just described. This well was completed about Nov. 1, 1893, and has been connected with the large collecting well by a siphon.

The driven-well system in the marsh near Loring Avenue has been reconstructed, and during 1893 water has been drawn, when necessary, from 39 tubular wells in this vicinity. The water of these wells is affected by their proximity to the sea, and the large amount of chlorine present at times in the water supplied to the town is due chiefly to the use of water from this source.

The large collecting well constructed in 1890 continues to be the chief source of supply, and at times furnishes all of the water used by the town.

*Chemical Examination of Water from the Large Collecting Well of the Marblehead Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |           |        | Residue on Evaporation. | AMMONIA. |               |           | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|-----------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment. | Color. |                         | Free.    | Albu- minoid. | Chlorine. | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1893.</b>        |                  |           |        |                         |          |               |           |             |           |                  |           |       |
| 11091   | Sept. 25            | Distinct.        | Slight.   | 0.10   | 15.40                   | .0030    | .0004         | 2.41      | .0700       | .0001     | .0697            | 8.0       | .1200 |
| 11165   | Oct. 10             | Distinct, milky. | None.     | 0.10   | 15.50                   | .0004    | .0012         | 2.93      | .0650       | .0001     | .0269            | 7.7       | .0450 |
| 11470   | Dec. 10             | Distinct, milky. | None.     | 0.10   | 16.10                   | .0014    | .0010         | 3.00      | .1000       | .0010     | .0360            | 8.9       | .0400 |
| Av.     | .....               | .....            | .....     | 0.10   | 15.77                   | .0016    | .0009         | 2.78      | .0793       | .0004     | .0442            | 8.2       | .0683 |

Odor, none. — The samples were collected either directly from the well or from a faucet at the pumping station while pumping from the well.

All of the waters in this and the two following tables contain iron in considerable amount, which oxidizes on exposure to the air, making the water somewhat turbid and colored.

*Microscopical Examination.*

No. 11091. Miscellaneous, Amorphous matter, 200.

No. 11165. Miscellaneous, Zoöglæa, 17.

No. 11470. No organisms.



**MARBLEHEAD.***Chemical Examination of Water from the Small Collecting Well, Marblehead.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |               |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|---------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment.     | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 11092   | 1893.<br>Sept. 25   | Distinct, milky. | Cons., rusty. | 0.70   | 13.00                   | .0084    | .0000       | 1.34      | .0070       | .0000     | .0820            | 6.9       | .2500 |

Odor, faintly unpleasant, disappearing on heating. — The sample was collected from the well.

*Microscopical Examination.*

Miscellaneous, *Zoöglæa*, 1,040.

*Chemical Examination of Water from Groups of Tubular Wells of the Marblehead Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                 |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|-----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment.       | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 11090   | 1893.<br>Sept. 25   | Decided, milky.  | Cons., fibrous. | 0.23   | 54.40                   | .0110    | .0000       | 17.82     | .0120       | .0001     | .0861            | 19.8      | .1900 |
| 11093   | Sept. 25            | Distinct, milky. | Slight, rusty.  | 0.75   | 13.20                   | .0046    | .0000       | 1.59      | .0050       | .0000     | .0633            | 7.6       | .2500 |
| 11166   | Oct. 10             | Distinct, milky. | Slight, rusty.  | 0.60   | 12.60                   | .0102    | .0008       | 1.45      | .0000       | .0000     | .0423            | 6.1       | .1900 |

Odor, none. — The first sample was collected from the group of thirty-nine tubular wells near Loring Avenue; the last two, from the group of five tubular wells located south-east of the pumping station.

Analyses of samples of water from the latter group of wells made in 1892 may be found on page 179 of the annual report of that year.

*Microscopical Examination.*

No. 11090. Fungi, *Crenothrix*, 3,600; Miscellaneous, *Zoöglæa*, 160. Total, 3,760.

No. 11093. Miscellaneous, *Zoöglæa*, 520.

No. 11166. Miscellaneous, *Zoöglæa*, 804.

## MARBLEHEAD.

*Chemical Examination of Water from the Wells of the Marblehead Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |            |        | Residue on Evaporation. | AMMONIA. |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|--------------------|------------|--------|-------------------------|----------|-----------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.         | Sediment.  | Color. |                         | Free.    | Alb-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 1893.   |                     |                    |            |        |                         |          |                 |           |             |           |                  |           |       |
| 9872    | Jan. 12             | None.              | Slight.    | 0.00   | 27.50                   | .0020    | .0010           | 8.69      | .0800       | .0000     | -                | 12.4      | .0160 |
| 9992    | Feb. 8              | Distinct, clayey.  | Slight.    | 0.03   | 47.70                   | .0010    | .0024           | 17.00     | .0750       | .0000     | .0365            | 19.6      | .0220 |
| 10108   | Mar. 13             | None.              | V. slight. | 0.02   | 29.70                   | .0000    | .0000           | 9.70      | .0550       | .0001     | .0577            | 13.6      | .0100 |
| 10246   | Apr. 12             | V. slight, clayey. | V. slight. | 0.03   | 16.20                   | .0028    | .0020           | 2.82      | .1000       | .0000     | .0255            | 2.8       | .0030 |
| 10375   | May 10              | None.              | None.      | 0.00   | 16.00                   | .0000    | .0012           | 3.04      | .1000       | .0001     | .0292            | 7.1       | .0060 |
| 10498   | June 8              | V. slight.         | None.      | 0.04   | 15.50                   | .0000    | .0006           | 2.06      | .0650       | .0000     | .0000            | 6.7       | .0120 |
| 10616   | July 7              | Slight, clayey.    | Slight.    | 0.02   | 13.90                   | .0008    | .0004           | 1.98      | .0650       | .0000     | .0146            | 6.9       | .0100 |
| 10790   | Aug. 14             | Slight, clayey.    | V. slight. | 0.01   | 23.00                   | .0000    | .0004           | 5.14      | .0400       | .0000     | .0181            | 8.4       | .0090 |
| 10998   | Sept. 11            | Distinct, clayey.  | V. slight. | 0.10   | 16.30                   | .0002    | .0014           | 2.19      | .0700       | .0000     | .0000            | 7.4       | .0150 |
| 11344   | Nov. 16             | Slight.            | V. slight. | 0.00   | 16.60                   | .0000    | .0006           | 3.12      | .1400       | .0000     | .0747            | 9.0       | .0120 |
| Av.     | .....               | .....              | .....      | 0.03   | 22.24                   | .0007    | .0010           | 5.57      | .0790       | .0000     | .0285            | 9.4       | .0115 |

Odor, none; occasionally an earthy odor is developed on heating. — The samples were collected from a faucet in the town, and represent a mixture of water drawn from the various sources of supply.

*Microscopical Examination.*

A very few *Zoëglæa* were found in March, April and May. In the remaining months the water contained no organisms.

## WATER SUPPLY OF MARLBOROUGH.

At the beginning of 1893, the new works to furnish an additional supply of water for the city of Marlborough from Millham Brook were nearly completed, and they were finished in season to permit the pumping of 38,000,000 gallons of water (nearly a quarter of the total amount consumed by the city in 1892) during the spring, when the flow in the brook was large. Of this amount 20,000,000 gallons were pumped directly into the distributing reservoir and the remainder into Lake Williams, which, at the beginning of the year, was at a much lower level than ever before. During the month of April the city was supplied wholly with water from Millham Brook.

The additional water works at present consist of a very small reservoir on Millham Brook, a pumping station near the reservoir, and a force main from which water can be discharged either into Lake Williams or, by means of a connection with the original force main, into the distributing reservoir.

## LEOMINSTER.

*Microscopical Examination of Water from Haynes Reservoir, Leominster.*

[Number of organisms per cubic centimeter.]

|                                   | 1895.     |            |              |              |               |          |
|-----------------------------------|-----------|------------|--------------|--------------|---------------|----------|
|                                   | Jan.      | March.     | May.         | Aug.         | Sept.         | Nov.     |
| Day of examination, . . . . .     | 23        | 21         | 23           | 1            | 26            | 27       |
| Number of sample, . . . . .       | 13698     | 14016      | 14353        | 14734        | 15242         | 15618    |
| <b>PLANTS.</b>                    |           |            |              |              |               |          |
| Diatomaceæ, . . . . .             | 9         | 25         | 3,150        | 350          | 750           | 4        |
| Asterionella, . . . . .           | 0         | 14         | 200          | 0            | 0             | 0        |
| Melosira, . . . . .               | 0         | 0          | 1,150        | 300          | 750           | 0        |
| Navicula, . . . . .               | 0         | 0          | 0            | 50           | 0             | 1        |
| Synedra, . . . . .                | 0         | 7          | 50           | 0            | 0             | 1        |
| Tabellaria, . . . . .             | 0         | 4          | 1,750        | 0            | 0             | 2        |
| Cyanophyceæ, . . . . .            | 2         | 9          | 150          | 2,450        | 9,600         | 9        |
| Anabaena, . . . . .               | 0         | 0          | 0            | 1,300        | 9,300         | 0        |
| Chroococcus, . . . . .            | 0         | 0          | 0            | 0            | 100           | 0        |
| Clathrocystis, . . . . .          | 1         | 0          | 150          | 1,000        | 200           | 0        |
| Cælophærium, . . . . .            | 1         | 0          | 0            | 50           | 0             | 0        |
| Microcystis, . . . . .            | 0         | 0          | 0            | 100          | 0             | 0        |
| Algæ, . . . . .                   | 24        | 3          | 250          | 650          | 350           | 1        |
| Closterium, . . . . .             | 0         | 0          | 50           | 0            | 0             | 0        |
| Pediastrum, . . . . .             | 0         | 0          | 50           | 50           | 0             | 0        |
| Protoecoccus, . . . . .           | 0         | 0          | 0            | 450          | 0             | 0        |
| Scenedesmus, . . . . .            | 0         | 3          | 100          | 150          | 250           | 0        |
| Staurostrum, . . . . .            | 0         | 0          | 50           | 0            | 100           | 1        |
| Tetrastroma, . . . . .            | 24        | 0          | 0            | 0            | 0             | 0        |
| Fungi, Crenothrix, . . . . .      | 0         | 194        | 100          | 0            | 0             | 9        |
| <b>ANIMALS.</b>                   |           |            |              |              |               |          |
| Infusoria, . . . . .              | 31        | 9          | 0            | 50           | 0             | 9        |
| Ciliated infusorian, . . . . .    | 0         | 1          | 0            | 0            | 0             | 0        |
| Dinobryon, . . . . .              | 3         | 0          | 0            | 0            | 0             | 0        |
| Dinobryon cases, . . . . .        | 6         | 1          | 0            | 0            | 0             | 0        |
| Euglena, . . . . .                | 2         | 0          | 0            | 0            | 0             | 0        |
| Mallomonas, . . . . .             | 1         | 0          | 0            | 0            | 0             | 0        |
| Peridinium, . . . . .             | 19        | 7          | 0            | 50           | 0             | 0        |
| Vermes, Polyarthra, . . . . .     | 1         | 0          | 0            | 0            | 0             | 9        |
| Miscellaneous, Zoöglæa, . . . . . | 0         | 112        | 300          | 0            | 0             | 2        |
| <b>TOTAL, . . . . .</b>           | <b>58</b> | <b>333</b> | <b>3,950</b> | <b>3,500</b> | <b>10,700</b> | <b>7</b> |

## MARLBOROUGH.

*Microscopical Examination of Water from Lake Williams, Marlborough.*

[Number of organisms per cubic centimeter.]

|                                      | 1893.     |            |            |           |
|--------------------------------------|-----------|------------|------------|-----------|
|                                      | March.    | July.      | September. | December. |
| Day of examination, . . . . .        | 31        | 3          | 30         | 23        |
| Number of sample, . . . . .          | 10191     | 10582      | 11105      | 11537     |
| <b>PLANTS.</b>                       |           |            |            |           |
| Diatomaceæ, . . . . .                | 2         | 55         | 8          | 6         |
| Asterionella, . . . . .              | 0         | 3          | 6          | 6         |
| Fragilaria, . . . . .                | 0         | 6          | 0          | 0         |
| Tabellaria, . . . . .                | 2         | 46         | 2          | 0         |
| Cyanophyceæ, Cælosphærium, . . . . . | 0         | 3          | 0          | 0         |
| Algæ, . . . . .                      | 35        | 124        | 0          | 0         |
| Chlorococcus, . . . . .              | 8         | 0          | 0          | 0         |
| Protococcus, . . . . .               | 0         | 124        | 0          | 0         |
| Zoospores, . . . . .                 | 27        | pr.        | 0          | 0         |
| <b>ANIMALS.</b>                      |           |            |            |           |
| Infusoria, . . . . .                 | 0         | 4          | 3          | 1         |
| Ceratium, . . . . .                  | 0         | 0          | 1          | 0         |
| Peridinium, . . . . .                | 0         | 1          | 1          | 1         |
| Trachelomonas, . . . . .             | 0         | 0          | 1          | 0         |
| Vorticella, . . . . .                | 0         | 3          | 0          | 0         |
| Vermes, Anurea, . . . . .            | 0         | 0          | 1          | 0         |
| Miscellaneous, Zoöglæa, . . . . .    | 34        | 18         | 40         | 0         |
| <b>TOTAL, . . . . .</b>              | <b>71</b> | <b>204</b> | <b>52</b>  | <b>7</b>  |

*Chemical Examination of Water from Millham Brook, Marlborough.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1893.   |                     |             |            |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 10192   | Mar. 29             | V. slight.  | Slight.    | 0.45   | 3.45                    | 0.95              | .0010    | .0146       | .0118      | .0028      | .20       | .0120       | .0000     | .4015            | 0.9       |
| 11536   | Dec. 20             | None.       | V. slight. | 0.60   | 6.15                    | 2.25              | .0006    | .0178       | .0154      | .0024      | .35       | .0300       | .0000     | .7006            | 2.1       |

Iron, .0073. Odor, faintly vegetable. — The samples were collected from Millham Brook at the point from which water is drawn for the supply of Marlborough.

*Microscopical Examination.*

No. 10192. Miscellaneous, Zoöglæa, 36.

No. 11536. Diatomaceæ, Meridion, 2; Synedra, 5; Miscellaneous, Zoöglæa, 5. Total, 12.

## MAYNARD.

## WATER SUPPLY OF MAYNARD.

*Chemical Examination of Water from the Maynard Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 10033   | Feb. 17             | V. slight.  | Slight.   | 0.05   | 2.55                    | 1.15              | .0000    | .0040       | .0030      | .0010      | .29       | .0000       | .0000     | .1297            | 0.9       |
| 10420   | May 18              | Slight.     | Slight.   | 0.01   | 2.15                    | 0.90              | .0000    | .0148       | .0126      | .0020      | .23       | .0000       | .0000     | .0949            | 0.2       |
| 10866   | Aug. 21             | Slight.     | Slight.   | 0.00   | 2.30                    | 1.00              | .0000    | .0104       | .0065      | .0036      | .24       | .0000       | .0000     | .1580            | 0.0       |
| 11368   | Nov. 22             | V. slight.  | Slight.   | 0.00   | 1.70                    | 0.50              | .0004    | .0132       | .0096      | .0036      | .25       | .0000       | .0000     | .1554            | 0.5       |
| Av.     | .....               | .....       | .....     | 0.02   | 2.18                    | 0.89              | .0001    | .0106       | .0080      | .0026      | .25       | .0000       | .0000     | .1345            | 0.4       |

Iron, .0033. Odor of the first sample, faintly earthy; of the second, distinctly vegetable and unpleasant; of the remaining samples, none. On heating, a faintly vegetable odor was noticeable in the second and third samples. — The first sample was collected from a faucet in the town, the remaining samples directly from the pond. The difference between the analysis of the sample collected in the village and those from the pond indicates that a large amount of ground water finds its way into the pipe leading from the pond to the pumping station.

*Microscopical Examination of Water from the Maynard Water Works.*

[Number of organisms per cubic centimeter.]

|                               | 1893.     |       |         |           |
|-------------------------------|-----------|-------|---------|-----------|
|                               | February. | May.  | August. | November. |
| Day of examination, . . . . . | 21        | 19    | 22      | 23        |
| Number of sample, . . . . .   | 10033     | 10420 | 10866   | 11368     |
| PLANTS.                       |           |       |         |           |
| Diatomaceæ, . . . . .         | 72        | 502   | 43      | 156       |
| Asterionella, . . . . .       | 42        | 8     | 0       | 106       |
| Cyclotella, . . . . .         | pr.       | 20    | 5       | 0         |
| Diatoma, . . . . .            | 1         | 0     | 4       | 0         |
| Navicula, . . . . .           | 1         | 0     | 2       | pr.       |
| Synedra, . . . . .            | 18        | 34    | 9       | 42        |
| Tabellaria, . . . . .         | 10        | 440   | 23      | 8         |
| Cyanophyceæ, . . . . .        | 0         | 4     | 44      | 7         |
| Clathrocystis, . . . . .      | 0         | 4     | 0       | 0         |
| Microcystis, . . . . .        | 0         | 0     | 44      | 7         |
| Algæ, . . . . .               | 0         | 3     | 4       | 10        |
| Conferva, . . . . .           | 0         | 2     | 0       | 0         |
| Protococcus, . . . . .        | 0         | 0     | 0       | 7         |
| Raphidium, . . . . .          | 0         | 0     | 4       | 2         |
| Scenedesmus, . . . . .        | 0         | 1     | 0       | 1         |

MAYNARD.

*Microscopical Examination of Water from the Maynard Water Works*  
— Concluded.

[Number of organisms per cubic centimeter.]

|                                          | 1893.     |      |         |           |
|------------------------------------------|-----------|------|---------|-----------|
|                                          | February. | May. | August. | November. |
| <b>ANIMALS.</b>                          |           |      |         |           |
| <b>Rhizopoda, Actinophrys,</b> . . . . . | 0         | 0    | 1       | 1         |
| <b>Infusoria,</b> . . . . .              | 4         | 37   | 3       | 37        |
| Dinobryon, . . . . .                     | 0         | 3    | 0       | 2         |
| Dinobryon cases, . . . . .               | 4         | 34   | 0       | 34        |
| Monas, . . . . .                         | 0         | pr.  | 1       | 0         |
| Peridinium, . . . . .                    | 0         | 0    | 2       | 1         |
| <b>Miscellaneous, Zoöglæa,</b> . . . . . | 5         | 22   | 8       | 66        |
| <b>TOTAL,</b> . . . . .                  | 81        | 568  | 108     | 277       |

## MEDFIELD.

*Chemical Examination of Water from a Spring, Medfield.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |              | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|--------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albo-minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 10241   | 1893.<br>April 12   | None.       | None.     | 0.0    | 3.00                    | .0004    | .0002        | .22       | .0030       | .0000     | .0693            | 1.1       | .0000 |

Odor, none, becoming very faintly vegetable on heating. — The sample was collected from a spring near Vine Brook about a third of a mile above North Street. This spring is used as a source of water supply by a large straw factory, and by a portion of the village of Medfield.

*Microscopical Examination.*Diatomææ, *Synedra*, 1.

## WATER SUPPLY OF MEDFIELD INSANE ASYLUM.

*Description of Works.* — This asylum is a State institution which had not been occupied up to the end of 1893. The water works were completed in September, 1893. The supply is obtained from a system of 20 two and one-half inch tubular wells, located on

## LOWELL.

exposure to the air, giving the water at first a milky turbidity, and subsequently precipitating in the form of a rusty sediment.

*Chemical Examination of Water from the Merrimack River above Lowell, opposite the Intake of the Lowell Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                     |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
|         | <b>1895.</b>        |                     |                   |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 13660   | Jan. 15             | Slight,<br>milky.   | Slight.           | .30    | 4.25                            | 1.25                 | .0076    | .0174       | .0148      | .0026           | .29       | .0040          | .0000     | .4345            | 1.6       |
| 13843   | Feb. 19             | Distinct.           | Slight.           | .28    | 4.35                            | 1.35                 | .0084    | .0158       | .0140      | .0018           | .25       | .0050          | .0000     | .4329            | 1.4       |
| 13999   | Mar. 19             | Slight.             | Cons.,<br>brown.  | .48    | 3.40                            | 1.15                 | .0026    | .0166       | .0134      | .0032           | .17       | .0070          | .0001     | .5925            | 0.8       |
| 14153   | Apr. 16             | Decided,<br>clayey. | Cons.,<br>earthy. | .53    | 3.40                            | 1.35                 | .0068    | .0296       | .0134      | .0162           | .13       | .0100          | .0001     | .6636            | 1.5       |
| 14335   | May 21              | Slight.             | Cons.             | .38    | 3.25                            | 1.35                 | .0014    | .0128       | .0088      | .0040           | .17       | .0080          | .0001     | .5016            | 1.3       |
| 14481   | June 18             | Distinct.           | Slight.           | .27    | 3.65                            | 1.55                 | .0008    | .0196       | .0124      | .0072           | .20       | .0050          | .0002     | .3838            | 0.8       |
| 14870   | Aug. 20             | Distinct.           | Slight.           | .38    | 4.45                            | 2.10                 | .0028    | .0150       | .0118      | .0032           | .22       | .0050          | .0001     | .3888            | 0.9       |
| 15183   | Sept. 17            | Slight.             | Slight.           | .22    | 3.55                            | 1.05                 | .0056    | .0170       | .0154      | .0016           | .26       | .0030          | .0001     | .3471            | 1.6       |
| 15369   | Oct. 15             | Distinct.           | Cons.             | .60    | 4.55                            | 1.80                 | .0000    | .0258       | .0198      | .0060           | .31       | .0070          | .0001     | .8034            | 1.6       |
| 15570   | Nov. 20             | Slight.             | Slight.           | .72    | 3.65                            | 1.55                 | .0004    | .0212       | .0162      | .0050           | .19       | .0070          | .0000     | .8408            | 1.1       |
| 15752   | Dec. 17             | Slight.             | Slight.           | .40    | 3.75                            | 1.60                 | .0060    | .0156       | .0144      | .0012           | .14       | .0120          | .0001     | .5298            | 1.1       |
| Av.     | .....               | .....               | .....             | .41    | 3.84                            | 1.46                 | .0039    | .0187       | .0140      | .0047           | .21       | .0066          | .0001     | .5353            | 1.2       |

*Averages by Years.*

|   |       |   |   |     |       |       |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|-------|-------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | .44 | 4.29  | 1.16  | .0021 | .0158 | -     | -     | .17 | .0094 | -     | -     | -   |
| - | 1888  | - | - | .30 | 3.42  | 0.97  | .0016 | .0160 | .0138 | .0027 | .16 | .0099 | .0002 | -     | -   |
| - | 1889  | - | - | .28 | 2.05† | 0.84† | .0018 | .0149 | .0126 | .0023 | .14 | .0071 | .0002 | -     | -   |
| - | 1890  | - | - | .30 | 3.67‡ | 1.54‡ | .0014 | .0128 | .0104 | .0024 | .13 | .0111 | .0001 | -     | 1.4 |
| - | 1891  | - | - | .29 | 3.43  | 1.23  | .0017 | .0129 | .0100 | .0029 | .13 | .0137 | .0001 | -     | 1.2 |
| - | 1892  | - | - | .39 | 3.61  | 1.36  | .0021 | .0141 | .0118 | .0028 | .14 | .0092 | .0001 | -     | 1.3 |
| - | 1893  | - | - | .33 | 3.39  | 1.18  | .0026 | .0149 | .0120 | .0029 | .17 | .0083 | .0001 | .4437 | 1.1 |
| - | 1894  | - | - | .35 | 3.55  | 1.26  | .0034 | .0135 | .0109 | .0026 | .18 | .0063 | .0001 | .3990 | 1.1 |
| - | 1895  | - | - | .41 | 3.84  | 1.46  | .0039 | .0187 | .0140 | .0047 | .21 | .0066 | .0001 | .5353 | 1.2 |

\* June to December.

† January to May.

‡ September to December.

NOTE to analyses of 1895: Odor, generally vegetable and musty or mouldy, sometimes unpleasant or disagreeable. — The samples were collected from the river, about 1 foot beneath the surface.

For a comparison of the analyses of the river at Lowell and Lawrence for a series of years, see "Merrimack River" in the chapter on "Examination of Rivers" in a subsequent portion of this report.

## MEDFORD.

two feet. These are approximately in two parallel lines and the extreme wells are about three hundred feet apart in an easterly and westerly direction, and one hundred and sixty feet in a northerly and southerly direction. As these wells did not furnish as much water as was desirable, in view of the low level of the water in Spot Pond, additional works were constructed early in 1894 for pumping water from the unpolluted upper portion of the brook.

Analyses of water from various sources within the town are given below. Further information regarding the water supply of Medford from Spot Pond may be found on pages 29-32 and 203, and analyses of water from the pond may be found on page 205.

*Chemical Examination of Water from Tubular Wells used as an Additional Source of Water Supply for Medford.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 10690   | 1893.<br>July 19    | None.       | None.     | 0.0    | 12.30                   | .0004    | .0002       | .70       | .0500       | .0000     | .0000            | 7.0       | .0040 |
| 10744   | Aug. 7              | None.       | None.     | 0.0    | 13.30                   | .0000    | .0000       | .64       | .0700       | .0000     | .0000            | 8.3       | .0040 |
| 11338   | Nov. 15             | None.       | None.     | 0.0    | 13.80                   | .0000    | .0000       | .86       | .0750       | .0000     | .0664            | 8.9       | .0000 |
| 11476   | Dec. 12             | None.       | None.     | 0.0    | 13.40                   | .0000    | .0000       | .85       | .0650       | .0000     | .0336            | 8.9       | .0000 |
| Av..... | .....               | .....       | .....     | 0.0    | 13.20                   | .0001    | .0001       | .76       | .0650       | .0000     | .0250            | 8.3       | .0020 |

Odor, none. — The samples were collected from a faucet at the temporary pumping station while pumping.

*Microscopical Examination.*

An insignificant number of organisms were found in the first and third samples; in the others no organisms were found.



**MEDFORD.**

*Chemical Examination of Water from Wells in Medford, collected during an Investigation for an Additional Water Supply.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|--------------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.         | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 9915    | 1893. Jan. 23       | None.              | None.      | 0.00   | 11.20                   | .0000    | .0000       | .79       | .0450       | .0000     | .0073            | 6.5       | .0040 |
| 9946    | Jan. 27             | "                  | "          | "      | "                       | "        | "           | .68       | .1250       | "         | "                | "         | "     |
| 9947    | Jan. 27             | "                  | "          | "      | "                       | "        | "           | .66       | .0450       | "         | "                | "         | "     |
| 9948    | Jan. 27             | "                  | "          | "      | "                       | "        | "           | .66       | .0450       | "         | "                | "         | "     |
| 9949    | Jan. 27             | "                  | "          | "      | "                       | "        | "           | .86       | .1200       | "         | "                | "         | "     |
| 10256   | April 17            | V. slight, clayey. | V. slight. | 0.05   | 14.60                   | .0000    | .0002       | .54       | .0700       | .0000     | .0000            | 8.4       | .0050 |
| 10257   | April 17            | Distinct, clayey.  | Slight.    | 0.02   | 12.00                   | .0000    | .0002       | .71       | .0600       | .0010     | .0000            | 6.3       | .0220 |

Odor, none. — No. 9946 was collected from a tubular well at a house on Fulton Street near Valley Street; No. 9949 from a well at a house on Webster Street near Forest Street; the remaining samples from tubular test wells, at the location from which the additional supply of water is drawn.

*Microscopical Examination.*

No. 10257. Miscellaneous, Zoöglæa, 20. Nos. 9915 and 10256, no organisms. Nos. 9946, 9947, 9948 and 9949, not examined.

*Chemical Examination of Water from a Brook near Forest Street, Medford.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 9914    | 1893.<br>Jan. 23    | V. slight.  | Cons.     | 0.20   | 5.30                    | 0.75              | .0044    | .0132       | .0118      | .0014      | .59       | .0150       | .0001     | .4051            | 2.2       |

Iron, .0100. Odor, very faintly vegetable. — The sample was collected from the brook near the corner of Elm and Forest streets, Medford. Early in 1894 the town began pumping water from the brook at this point.

*Microscopical Examination.*

Diatomaceæ, *Meridion*, 1; *Naricula*, 1; *Nitzschia*, 1. Miscellaneous, Zoöglæa, 11. Total, 14.

**WATER SUPPLY OF MELROSE.**

Several communications of the State Board of Health to the town of Melrose, with reference to taking an additional water supply for the town from sources in North Andover, and from various sources within the town of Melrose, may be found on pages 34-40 of this volume.

**MELROSE.**

In August, 1893, an additional supply of water was introduced from a system of tubular wells, owned by a private company, and located in the westerly part of the town, near the boundary line between Melrose and Stoneham. The works consist of a system of fifteen two and one-half inch tubular wells varying in depth from thirty-five to forty-five feet, all located in the vicinity of Spot Pond Brook, north of Wyoming Avenue. The wells are connected with a temporary pump, and water is pumped directly into the main pipe in Wyoming Avenue, which conveys water from Spot Pond to the town.

Analyses of water from this source and from other sources within the town are given in the tables below. Further information regarding the water supply of Melrose from Spot Pond may be found on pages 29-32 and 203, and analyses of water from the pond on page 205.

*Chemical Examination of Water from Tubular Wells in the Valley of Spot Pond Brook, near Wyoming Avenue, used as an Additional Source of Water Supply for Melrose.*

[Parts per 100,000.]

| Number.  | Date of Collection. | APPEARANCE.        |                 |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|----------|---------------------|--------------------|-----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|          |                     | Turbidity.         | Sediment.       | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|          | 1893.               |                    |                 |        |                         |          |             |           |             |           |                  |           |       |
| 10692    | July 20             | V. slight, clayey. | V. slight.      | 0.02   | 8.90                    | .0000    | .0024       | 0.69      | .0200       | .0000     | .0370            | 3.9       | .0000 |
| 10867    | Aug. 21             | Distinct.          | Slight.         | 0.02   | 9.20                    | .0004    | .0000       | 0.71      | .0000       | .0003     | .0474            | 4.4       | .0070 |
| 10989    | Sept. 6             | None.              | None.           | 0.00   | 9.00                    | .0000    | .0008       | 0.81      | .0000       | .0001     | .0312            | 4.3       | .0312 |
| 11118    | Sept. 29            | None.              | None.           | 0.00   | 10.40                   | .0000    | .0018       | 1.17      | .1500       | .0000     | .0385            | 6.0       | .0080 |
| 11164    | Oct. 11             | None.              | None.           | 0.00   | 11.40                   | .0000    | .0018       | 1.25      | .1100       | .0001     | .0077            | 6.3       | .0040 |
| 11348    | Nov. 16             | Distinct, clayey.  | Slight, clayey. | 0.05   | 12.80                   | .0000    | .0000       | 1.37      | .0900       | .0000     | .0468            | 7.3       | .0250 |
| 11497    | Dec. 14             | None.              | None.           | 0.00   | 12.00                   | .0006    | .0020       | 1.25      | .0800       | .0000     | .0280            | 5.9       | .0050 |
| Av. .... | .....               | .....              | .....           | 0.01   | 10.53                   | .0001    | .0013       | 1.04      | .0614       | .0000     | .0338            | 5.4       | .0115 |

Odor, none. — The first two samples were collected from the discharge pipe of the pump drawing water from the tubular wells; the remaining samples from a faucet at the temporary pumping station while pumping.

*Microscopical Examination.*

A few *Zoëglæ* were found in the samples collected in the latter part of September and in October and November. In the remaining samples no organisms were found.

**MELROSE.***Chemical Examination of Water from a Group of Five Tubular Test Wells near Ell Pond, Melrose.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.      | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 9898    | 1893.<br>Jan. 17    | None.       | None.          | 0.0    | 10.00                   | .0000    | .0000       | 1.13      | .2500       | .0000     | .0511            | 5.3       | .0010 |
| 9942    | Jan. 25             | None.       | None.          | 0.0    | 11.25                   | .0000    | .0018       | 1.30      | .1250       | .0001     | .0219            | 5.6       | .0010 |
| 9958    | Jan. 31             | None.       | None.          | 0.0    | 11.30                   | .0000    | .0012       | 1.14      | .1900       | .0005     | .0219            | 6.1       | .0000 |
| 10541   | June 21             | V. slight.  | Slight, brown. | 0.0    | 10.40                   | .0000    | .0000       | 1.08      | .2200       | .0000     | .0000            | 3.6       | .0300 |
| Av...   | .....               | .....       | .....          | 0.0    | 10.76                   | .0000    | .0008       | 1.16      | .1963       | .0002     | .0631            | 5.2       | .0090 |

Odor, none. — The first three samples were collected during a pumping test from a group of five tubular wells about fifty feet distant from the northerly shore of Ell Pond. The first sample was collected soon after beginning the test and the third sample at the end, after pumping fourteen and a half days at a rate of about 480,800 gallons per day. The last sample was collected from a small hand pump after pumping a few minutes from one of the wells. The average depth of these wells was 38 feet.

*Microscopical Examination.*

No. 10541. Fungi, *Spirocheta*, 2. No organisms were found in the remaining samples.

*Chemical Examination of Water from a Group of Three Six-inch Tubular Test Wells near Ell Pond, Melrose.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 10542   | 1893.<br>June 21    | V. slight.  | Slight.   | 0.0    | 11.50                   | .0000    | .0000       | 1.17      | .2300       | .0001     | .0079            | 3.6       | .0300 |
| 10584   | July 3              | None.       | None.     | 0.0    | 10.70                   | .0000    | .0000       | 1.12      | .2000       | .0001     | .0079            | 3.8       | .0000 |

Odor, none. — The samples were collected from a group of three tubular test wells each six inches in diameter, located about 175 feet from Ell Pond and about 350 feet from Tremont Street, Melrose. The first sample was collected from the middle well of the group; the last sample from a pipe discharging water from a temporary pump drawing water from all three wells after pumping for three days at a rate of about 140,000 gallons per day.

*Microscopical Examination.*

No. 10542. Diatomaceæ, *Tabellaria*, 2. No. 10584. No organisms.

## MELROSE.

*Chemical Examination of Water from Tubular Wells in the vicinity of Spot Pond Brook, North of Wyoming Avenue, near the Boundary between Melrose and Stoneham.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |              |        | Residue on Evaporation. | AMMONIA. |             |  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|--------------|--------|-------------------------|----------|-------------|--|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment.    | Color. |                         | Free.    | Albuminoid. |  |           | Nitrates.   | Nitrites. |                  |           |       |
| 10018   | 1893.<br>Feb. 13    | Decided.         | Cons., gray. | 0.15   | 10.80                   | .0126    | .0030       |  | .70       | .0400       | .0014     | .1147            | 4.7       | .1065 |
| 10036   | Feb. 20             | Distinct, milky. | Cons.        | 0.10   | 8.90                    | .0090    | .0026       |  | .77       | .0180       | .0015     | .0322            | 5.6       | .0280 |

Note, — These wells were about 1,000 feet north-west of the wells from which the auxiliary supply of Melrose is drawn.

Odor of the first sample, distinctly earthy; of the last, none. — The samples were collected from the wells while pumping.

*Microscopical Examination.*

No organisms.

*Chemical Examination of Water from Ell Pond, Melrose.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 9897    | 1893.<br>Jan. 18    | Distinct.   | Cons.     | 0.30   | 10.15                   | 2.60              | .0388    | .0194       | .0166      | .0028      | 1.47      | .1200       | .0011     | .3285            | 3.8       |

Iron, .0200. Odor, distinctly vegetable. — The sample was collected from the pond near the middle. This pond is not used as a source of water supply.

*Microscopical Examination.*

Diatomaceæ, *Asterionella*, 24; *Cyclotella*, 2; *Melosira*, 454; *Synedra*, 5. Cyanophyceæ, *Clathrocystis*, 1. Algae, *Chlorococcus*, 3; *Closterium*, 1; *Protococcus*, 37; *Raphidium*, 3; *Scenedesmus*, 2. Infusoria, *Trachelomonas*, 14; *Vorticella*, 1. Miscellaneous, *Acarina*, .02; *Zoöglæa*, 100. Total, 647.

## MENDON.

## MENDON.

The advice of the State Board of Health to the town of Mendon, with reference to taking a water supply for the town from Mendon Pond, also known as Nipmuck Pond, may be found on pages 40-41 of this volume.

The advice of the Board to the town of Uxbridge with reference to the use of this pond as a source of water supply for that town is given in the annual report for 1892, pages 46-49. For analyses of samples of water collected from Mendon Pond, see Uxbridge.

## WATER SUPPLY OF METHUEN.

The advice of the State Board of Health to the town of Methuen with reference to obtaining a water supply for the town from the ground in the vicinity of Sargent's Brook, and, subsequently, with reference to obtaining a water supply from the ground in the vicinity of the Spicket River near the point where it is joined by the brook flowing from Harris Pond, may be found on pages 41-42 of this volume. Works for supplying the town with water from wells in the vicinity of the Spicket River were begun near the end of 1893.

*Chemical Examination of Water from the Spicket River at Mouth of Harris Pond Brook, and from a Tubular Well in the Vicinity.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.     |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |           | Chlorine. | NITROGEN AS |            | Oxygen Consumed. | Hardness. |
|---------|---------------------|-----------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|-----------|-----------|-------------|------------|------------------|-----------|
|         |                     | Turbidity.      | Sediment.       | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            | Nitrates. |           | Nitrites.   |            |                  |           |
|         |                     |                 |                 |        |                         |                   |          | Total.      | Dissolved. |           |           |             | Suspended. |                  |           |
| 1893.   |                     |                 |                 |        |                         |                   |          |             |            |           |           |             |            |                  |           |
| 10616   | July 7              | V. slight.      | V. slight.      | 0.60   | 3.85                    | 1.90              | .0012    | .0230       | .0180      | .0050     | .18       | .0000       | .0000      | .6278            | 1.3       |
| 10617   | July 7              | Slight, clayey. | Slight, earthy. | 0.02   | 7.00                    | -                 | .0000    | .0000       | -          | -         | .23       | .0200       | .0000      | .0000            | 2.2       |

Iron, in the first sample, .0040; in the last, .0270. Odor of the first sample, distinctly vegetable and mouldy; of the last sample, none. — The first sample was collected from the Spicket River near the mouth of the brook flowing from Harris Pond; the last sample, from a tubular well near the river in the same locality.

*Microscopical Examination.*

No. 10616. Diatomaceæ, *Cyclotella*, 1. Algae, *Protococcus*, 2; *Raphidium*, 2; *Zoöspores*, 1. Fungi, *Crenothrix*, 38. Miscellaneous, *Zoöglæa*, 48. Total, 92.

No. 10617. Miscellaneous, *Zoöglæa*, 58.

## METHUEN.

*Chemical Examination of Water from a Brook and Tubular Test Wells in Sargent's Meadow, Methuen.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.    |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|----------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.     | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1893.</b>        |                |            |        |                         |          |             |           |             |           |                  |           |       |
| 10277   | Apr. 20             | None.          | V. slight. | 0.12   | 3.50                    | .0006    | .0056       | .24       | .0100       | .0000     | .1971            | 1.4       | .0040 |
| 10276   | Apr. 20             | None.          | None.      | 0.02   | 3.40                    | .0000    | .0002       | .31       | .0050       | .0000     | .0146            | 1.1       | .0070 |
| 10376   | May 8               | Slight, milky. | V. slight. | 0.02   | 7.65                    | .0168    | .0010       | .25       | .0070       | .0003     | .0730            | 3.0       | .0210 |
| Av.     | .....               | .....          | .....      | 0.05   | 4.85                    | .0058    | .0023       | .27       | .0073       | .0001     | .0949            | 1.8       | .0107 |

Odor of the first two samples, none; of the last, faint. — The first sample was collected from a brook in Sargent's Meadow, in the easterly part of Methuen. This brook is a tributary of Bear Meadow Brook. The last two samples were from tubular wells in Sargent's Meadow; the first from a single well and the last from a group of seven two and one-half inch tubular wells, collected from the discharge pipe of a pump after pumping continuously for eight hours.

*Microscopical Examination.*

No. 10276. No organisms.

No. 10277. Diatomaceæ, *Meridion*, 16; *Synedra*, 4. Total, 20.No. 10376. Diatomaceæ, *Asterionella*, 2.

## WATER SUPPLY OF MIDDLEBOROUGH FIRE DISTRICT. — MIDDLEBOROUGH.

*Chemical Examination of Water from the Well of the Middleborough Fire District.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1893.</b>        |             |            |        |                         |          |             |           |             |           |                  |           |       |
| 10242   | Apr. 12             | None.       | None.      | 0.00   | 7.25                    | .0012    | .0020       | .78       | .1200       | .0001     | .0511            | 2.6       | .0010 |
| 11013   | Sept. 12            | V. slight.  | V. slight. | 0.10   | 5.80                    | .0000    | .0028       | .68       | .0350       | .0000     | .1170            | 2.5       | .0130 |

Odor, none. — The samples were collected from a faucet at the pumping station while pumping.

*Microscopical Examination.*No. 10242. Diatomaceæ, *Asterionella*, 3; *Synedra*, 9. Total, 12.

No. 11013. Diatomaceæ, *Pinnularia*, 1; Fungi, *Oreothrix*, 100; Infusoria, *Peridinium*, 1. Total, 102.

## WATER SUPPLY OF MIDDLETON.

(See *Danvers*.)

## MILLIS.

## WATER SUPPLY OF MILLIS. — MILLIS WATER COMPANY.

*Chemical Examination of Water from the Aqua Rex Spring, Millis.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albu- minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 10034   | Feb. 20.            | None.       | None.      | 0.00   | 5.30                    | .0006    | .0048         | .48       | .1200       | .0000     | .0472            | 2.6       | .0000 |
| 10434   | May 22              | None.       | None.      | 0.00   | 5.30                    | .0022    | .0004         | .40       | .1200       | .0000     | .0487            | 1.9       | .0000 |
| 10868   | Aug. 22             | None.       | None.      | 0.00   | 6.70                    | .0000    | .0006         | .42       | .1500       | .0000     | .0000            | 2.1       | .0000 |
| 11346   | Nov. 17             | None.       | V. slight. | 0.03   | 5.75                    | .0000    | .0082         | .44       | .1440       | .0000     | .0858            | 2.2       | .0020 |
| 11565   | Dec. 29.            | None.       | None.      | 0.00   | 5.30                    | .0000    | .0002         | .42       | .1250       | .0000     | .0000            | 2.1       | .0050 |
| AV...   | .....               | .....       | .....      | 0.01   | 5.67                    | .0006    | .0028         | .43       | .1318       | .0000     | .0363            | 2.2       | .0014 |

Odor of No. 11346, faint, becoming very disagreeable on standing three days; of the remaining samples, none. — The samples were collected from the spring. No. 11346 had obviously been exposed to the light.

*Microscopical Examination of Water from Aqua Rex Spring, Millis.*

[Number of organisms per cubic centimeter.]

| 1893.                           |           |       |         |           |           |
|---------------------------------|-----------|-------|---------|-----------|-----------|
|                                 | February. | May.  | August. | November. | December. |
| Day of examination, . . . . .   | 21        | 23    | 22      | 18        | 30        |
| Number of sample, . . . . .     | 10034     | 10434 | 10868   | 11346     | 11565     |
| PLANTS.                         |           |       |         |           |           |
| Diatomaceæ, Navicula, . . . .   | 5         | 0     | 0       | 0         | 0         |
| Infusoria, Chlamydomonas, . .   | 0         | 0     | 0       | 130       | 0         |
| Miscellaneous, Zoöglæa, . . . . | 2         | 0     | 0       | 22        | 0         |
| TOTAL, . . . . .                | 7         | 0     | 0       | 152       | 0         |

## MILTON.

## WATER SUPPLY OF MILTON. — MILTON WATER COMPANY.

The water supplied by this company to the town is purchased from the Hyde Park Water Company. A statement in regard to the supply and analyses of the water may be found on pages 173-176. Analyses of samples of water from Pine Tree Brook, and from a test well near it, made in connection with an investigation for a new source of water supply for Milton, are given below.

*Chemical Examination of Water from Pine Tree Brook, Milton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 11429   | 1893.<br>Nov. 30    | None.       | V. slight. | 0.85   | 5.55                    | 2.15              | .0000    | .0216       | .0198      | .0018      | .75       | .0030       | .0000     | .9438            | 1.1       |

Iron, .0100. Odor, faintly vegetable, becoming stronger on heating. — The sample was collected from the brook at the site of a small dam on the westerly side of Harland Street, Milton.

*Microscopical Examination.*

Fungi, *Crenothrix*, 1. Miscellaneous, *Zooglaea*, 3. Total, 4.

*Chemical Examination of Water from a Tubular Test Well in the Valley of Pine Tree Brook, Milton.*

[Parts per 100,000.]

| Number. | Date of<br>Collection. | APPEARANCE. |                 |        | Residue on<br>Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN<br>AS |           | Oxygen<br>Consumed. | Hardness. | Iron. |
|---------|------------------------|-------------|-----------------|--------|----------------------------|----------|------------------|-----------|----------------|-----------|---------------------|-----------|-------|
|         |                        | Turbidity.  | Sediment.       | Color. |                            | Free.    | Albu-<br>minoid. |           | Nitrates.      | Nitrites. |                     |           |       |
|         |                        |             |                 |        |                            |          |                  |           |                |           |                     |           |       |
| 11430   | 1893.<br>Nov. 30       | None.       | Cons.,<br>sand. | 0.0    | 4.70                       | .0000    | .0000            | .43       | .1500          | .0000     | .0000               | 1.9       | .0000 |

Odor, none. — The sample was collected from a tubular well near Pine Tree Brook on the easterly side of Harland Street, and about 700 feet south of Canton Avenue, Milton.

*Microscopical Examination.*

No organisms.



## MONTAGUE.

## WATER SUPPLY OF TURNER'S FALLS FIRE DISTRICT. — MONTAGUE.

*Chemical Examination of Water from Lake Pleasant, Montague.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. |           |  |
|---------|---------------------|-------------|-------------------|--------|-------------------------|-------------------|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------|--|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.   | Nitrites. | Oxygen Consumed. | Hardness. |  |
|         |                     |             |                   |        |                         |                   |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |           |  |
| 1893.   |                     |             |                   |        |                         |                   |          |             |            |                 |           |             |           |                  |           |  |
| 9928    | Jan. 23             | V. slight.  | V. slight.        | 0.03   | 3.30                    | 1.20              | .0090    | .0482       | .0326      | .0156           | .16       | .0000       | .0000     | .2190            | 0.5       |  |
| 9972    | Feb. 6              | V. slight.  | V. slight.        | 0.04   | 2.65                    | 0.90              | .0064    | .0138       | .0098      | .0040           | .15       | .0050       | .0001     | .1153            | 0.9       |  |
| 10136   | Mar. 16             | Slight.     | Slight,<br>white. | 0.08   | 1.20                    | 0.55              | .0012    | .0060       | .0032      | .0028           | .10       | .0030       | .0001     | .0864            | 0.5       |  |
| 10168   | Mar. 27             | None.       | Slight.           | 0.02   | 2.20                    | 0.60              | .0042    | .0066       | .0046      | .0020           | .10       | .0150       | .0001     | .0985            | 0.6       |  |
| 10259   | Apr. 17             | V. slight.  | V. slight.        | 0.04   | 2.25                    | 0.30              | .0014    | .0082       | .0048      | .0034           | .09       | .0000       | .0000     | .0912            | 0.5       |  |
| 10392   | May 15              | V. slight.  | V. slight.        | 0.03   | 2.25                    | 0.25              | .0000    | .0072       | .0054      | .0018           | .09       | .0180       | .0000     | .1022            | 0.3       |  |
| 10516   | June 13             | V. slight.  | None.             | 0.03   | 2.85                    | 1.20              | .0002    | .0100       | .0082      | .0018           | .14       | .0030       | .0000     | .0703            | 0.3       |  |
| 10653   | July 12             | None.       | V. slight.        | 0.02   | 1.80                    | 0.35              | .0000    | .0054       | .0040      | .0014           | .10       | .0050       | .0000     | .0949            | 0.1       |  |
| 10812   | Aug. 15             | V. slight.  | Slight.           | 0.01   | 1.90                    | 0.60              | .0000    | .0064       | .0054      | .0010           | .10       | .0000       | .0000     | .0987            | 0.8       |  |
| 11022   | Sept. 13            | None.       | V. slight.        | 0.03   | 2.50                    | 0.85              | .0000    | .0074       | .0052      | .0022           | .12       | .0050       | .0000     | .0936            | 0.5       |  |
| 11162   | Oct. 10             | V. slight.  | V. slight.        | 0.05   | 2.30                    | 0.75              | .0000    | .0092       | .0070      | .0022           | .12       | .0000       | .0000     | .0885            | 0.5       |  |
| 11328   | Nov. 13             | None.       | V. slight.        | 0.08   | 1.95                    | 0.55              | .0018    | .0054       | .0044      | .0010           | .11       | .0040       | .0000     | .1867            | 0.5       |  |
| 11471   | Dec. 11             | None.       | V. slight.        | 0.08   | 2.15                    | 0.60              | .0060    | .0100       | .0084      | .0016           | .11       | .0050       | .0000     | .1120            | 0.6       |  |
| Av.*    | .....               | .....       | .....             | 0.04   | 2.28                    | 0.68              | .0023    | .0115       | .0083      | .0032           | .12       | .0045       | .0000     | .1137            | 0.6       |  |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887† | - | - | 0.03 | 2.74 | 0.81 | .0018 | .0116 | -     | -     | .10 | .0007 | -     | -     | -   |
| - | 1888  | - | - | 0.00 | 2.33 | 0.49 | .0027 | .0071 | -     | -     | .09 | .0085 | .0000 | -     | -   |
| - | 1889† | - | - | 0.01 | 2.19 | 0.40 | .0008 | .0063 | .0052 | .0011 | .09 | .0088 | .0000 | -     | -   |
| - | 1893  | - | - | 0.04 | 2.28 | 0.68 | .0023 | .0115 | .0083 | .0032 | .12 | .0045 | .0000 | .1137 | 0.6 |

\* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

† June to December.

‡ January to June.

NOTE to analyses of 1893; Iron, .0065. Odor of the first sample, strongly vegetable and unpleasant, becoming strongly oily on heating; of the second sample, none, becoming decidedly oily on heating; of the last sample, decidedly vegetable and unpleasant; of the remaining samples, generally faintly vegetable or none. — The first three samples were collected directly from the lake; the remaining samples from a faucet at the pumping station.

## MONTAGUE.

*Microscopical Examination of Water from Lake Pleasant, Montague.*

[Number of organisms per cubic centimeter.]

|                               | 1893. |      |       |       |       |       |       |       |       |       |       |             |
|-------------------------------|-------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------------|
|                               | Jan.  | Feb. | Mar.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov. Dec.   |
| Day of examination, . . .     | 25    | 7    | 18    | 28    | 18    | 16    | 14    | 15    | 16    | 14    | 11    | 14 12       |
| Number of sample, . . .       | 9928  | 9972 | 10136 | 10168 | 10259 | 10392 | 10516 | 10653 | 10812 | 11022 | 11162 | 11328 11471 |
| PLANTS.                       |       |      |       |       |       |       |       |       |       |       |       |             |
| Diatomaceæ, . . .             | 2     | 0    | pr.   | 48    | 445   | 8     | 44    | 1     | 19    | pr.   | 19    | 153 24      |
| Cyclotella, . . .             | pr.   | 0    | 0     | pr.   | 3     | 0     | 12    | pr.   | 0     | 0     | 0     | 4 24        |
| Fragilaria, . . .             | 0     | 0    | 0     | 0     | 5     | 0     | 14    | 1     | 14    | 0     | 0     | 3 0         |
| Melosira, . . .               | 0     | 0    | 0     | 10    | 4     | 6     | 12    | 0     | 3     | 0     | 19    | 144 0       |
| Synedra, . . .                | 2     | 0    | pr.   | 39    | 430   | 2     | 4     | 0     | 0     | pr.   | 0     | 0 0         |
| Tabellaria, . . .             | 0     | 0    | 0     | 0     | 3     | 0     | 2     | 0     | 2     | pr.   | 0     | 2 0         |
| Algæ, . . .                   |       |      |       |       |       |       |       |       |       |       |       |             |
| Chlorococcus, . . .           | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 73    | 3 0         |
| Pandorina, . . .              | 0     | 0    | 0     | 0     | 0     | 0     | pr.   | 0     | 0     | 10    | 0     | 0 0         |
| Protococcus, . . .            | 0     | 0    | 0     | 0     | 0     | 0     | 17    | 0     | 50    | 0     | 0     | 12 0        |
| ANIMALS.                      |       |      |       |       |       |       |       |       |       |       |       |             |
| Infusoria, . . .              | 9     | 510  | pr.   | 3     | 2     | 0     | 0     | 0     | 1     | pr.   | 0     | 6 33        |
| Dinobryon, . . .              | 0     | 196  | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0 3         |
| Dinobryon cases, . . .        | 9     | 314  | 0     | 3     | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 6 26        |
| Peridinium, . . .             | 0     | 0    | pr.   | 0     | 0     | 0     | 0     | 0     | 0     | pr.   | 0     | 0 4         |
| Vermes, Rotatorian ova, . . . | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | pr. 0       |
| Miscellaneous, Zoöglæa, . . . | 0     | 0    | 0     | 16    | 8     | 0     | 1     | 0     | 0     | 0     | 7     | 2 0         |
| TOTAL, . . .                  | 11    | 510  | pr.   | 68    | 455   | 8     | 62    | 1     | 72    | 12    | 99    | 176 57      |

## WATER SUPPLY OF NAHANT.

(See *Swampscott.*)

## WATER SUPPLY OF NANTUCKET. — WANNACOMET WATER COMPANY.

Wannacomet Pond, the source of supply of this company, has given trouble on several occasions owing to the presence in the water of abundant growths of the organism *Anabæna*, which has generally appeared about midsummer and disappeared in October. The pond is a natural basin with sandy shores and a muddy bottom, having an area of about eight acres and a general depth of about fourteen feet. It has no visible inlet or outlet and is supplied with water which percolates into it from the sandy territory with which

## NANTUCKET.

the pond is surrounded. In 1891 the *Anabæna* gave more serious trouble than in any previous year, and in order to provide a remedy in the event of any recurrence of the trouble a filter was constructed near the shore of the pond for use at such times. In 1892 the pond was wholly free from these organisms, and there was no occasion to use the filter; but in 1893 the organisms reappeared in great numbers, and the filter was used nearly all of the time from August 8 to October 18.

A description of the filter and an account of the results obtained by its use during the period above indicated are contained in a paper read by Mr. W. F. Codd, superintendent of the works, before the New England Water Works Association, and many of the following statements are taken from this paper. The subject is a particularly interesting one because it is the first attempt to filter in this manner a water containing large numbers of algæ.

In constructing the filter a water-tight circular basin or reservoir, sixty-four feet in diameter at the bottom and six feet deep, with slopes of two horizontal to one vertical, was first made. The bottom of this basin consisted of a layer of puddle, one foot in thickness, and the slopes were formed of the same material. In the centre a circular brick well was built to collect the filtered water, 15.25 feet in diameter inside and eight feet deep. The bottom of this well is of concrete and is somewhat lower than the bottom of the filter. The construction of the filter proper was then begun by covering the clay bottom with a layer of sand one inch in thickness, over which was placed a layer of round and broken stones about two feet in thickness. Imbedded in the layer of stones are four main lines of twelve-inch vitrified pipe, each having six branches extending out from each side, designed to collect the filtered water and convey it to the collecting well. Above the layer of stones is a six-inch layer of gravel, and then a layer of filtering sand from twelve to sixteen inches in thickness, which was placed in three layers, each rolled with a stone-roller. Wrought-iron aeration pipes, perforated with holes, three thirty-seconds of an inch in diameter and two feet apart, were laid in the bottom of the collecting well and inside of every vitrified pipe under the filter bed, it being the intention to aerate not only the filtered water but the filter bed itself.

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The surface of the filter is level and about five feet above high-water mark in the pond, so that water has to be pumped upon it. The pond water is pumped through a six-inch pipe which rises vertically through the filtering material to the surface of the filter, and the water is kept at a depth of from twelve to eighteen inches above the surface of the sand. The filter was kept saturated and covered with water at all times, although, as it was the custom to pump water upon the filter and draw the filtered water from the collecting well at the same time, the filtration through the sand took place only while the pumps were in operation. As a rule air was forced through the aeration pipes during most of the time when the pumping was in progress.

The rate of consumption during the summer ranged from 150,000 to 220,000 gallons per day, so that the rate of filtration if it had been continued through the whole twenty-four hours would have been from 1,420,000 to 2,080,000 gallons per acre per day (1.4 to 2.0 gallons per square foot per hour). The pumps were generally operated from an hour to an hour and a half at a time, while the tank was being filled, and then shut down for three or four hours. Under these circumstances the filtration took place at a much more rapid rate than is above indicated. It is stated that the filter is intended to operate at the rate of five gallons per square foot per hour.

As already indicated, the *Anabæna* appeared in such numbers in 1893 as to cause complaint from the water consumers, and the operation of the filter was begun on August 8. At first the results appeared to be satisfactory, 98 per cent. of the organisms being removed from the water on August 14, and nearly all of the odor and color. After twelve days' use, while the filtered water still appeared to be clear, complaints of the odor of the water began to be made by the consumers. Two days later it was noticed that a scum had formed upon the surface of the sand and the filter had become clogged. This clogging was relieved by raking the surface, and did not occur again. After twenty-two days' use the odor of the filtered water was so strong that the use of the filter was discontinued, the water was drawn down and a layer half an inch in depth was removed from the surface of the filter. The greater part of the matter removed from the water by filtration was found within a

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quarter of an inch of the surface. In some places, however, the sand was stained to a depth of eight or ten inches. It was also noticed that the air used in aerating the filter had passed up through the material unevenly and had come to the surface at several places where little craters were formed. The portion of the aerating pipes extending beneath the filter bed were accordingly disconnected and were not used again during the season. The filter was again used for a few days beginning September 1, but the odor of the filtered water was so strong that it was again discontinued. Up to this time light was admitted to the collecting well, but afterward it was excluded.

It is also to be noted that these unfavorable results were obtained during the portion of the year when the pond water had a high temperature, which was increased by the exposure of the water in a thin layer upon the filter bed and by the warm air pumped in for aeration from the engine-room. After September 29, when the temperature of the water was below sixty degrees Fahrenheit, the filter was operated without any trouble and there was said to be no odor. On October 18 the filtration was discontinued for the season, as the *Anabæna* had disappeared from the pond.

The results of the chemical and microscopical examinations as given in the following tables show that a very large proportion of the *Anabæna* were at all times removed by filtration, but at times there was a very abundant development of *Zoöglæa* in the filtered water. For instance, in the sample collected on September 20, when the unfiltered water contained 508 *Anabæna* and *Anabæna* spores per cubic centimeter, the number in the filtered water was 63. In the unfiltered water there were no *Zoöglæa* and in the filtered water 480. On this date the amount of organic matter as indicated by the albuminoid ammonia was reduced only about one-fourth, but as a rule nearly three-fifths of the organic matter was removed by filtration.

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*Comparison of Examinations of Water from the Wannacomel Water Company's Works before and after Filtration.*

[NOTE.— Figures in bold-faced type show the results of examinations of water from the pond. Figures in Roman type show results of examinations of the water after passing through the filter.]

[Parts per 100,000.]

| Date of Collection. | APPEARANCE.       |                 | ODOR.                               |                                     | AMMONIA. |             | Oxygen Consumed. | Anhydrous per Cubic Centimeter. | Zincless per Cubic Centimeter. |
|---------------------|-------------------|-----------------|-------------------------------------|-------------------------------------|----------|-------------|------------------|---------------------------------|--------------------------------|
|                     | Turbidity.        | Sediment.       | Cold.                               | Hot.                                | Free.    | Albuminoid. |                  |                                 |                                |
| <b>1893.</b>        |                   |                 |                                     |                                     |          |             |                  |                                 |                                |
| Aug. 14             | De'ded, green.    | Cons., rusty.   | Distinctly disagreeable.            | Dist'ly v'g'ble and grassy.         | .0110    | .0526       | .2607            | 2,224                           | 144                            |
| Aug. 14             | None.             | None.           | Faintly disagreeable.               | Faintly vegetable.                  | .0000    | .0168       | .1461            | 36                              | 1                              |
| Aug. 22             | De'ded, green.    | Slight, yellow. | Dist'ly v'g'ble & disag'ble.        | Dist'ly v'g'ble and grassy.         | .0002    | .0590       | .2646            | 1,100                           | 76                             |
| Aug. 22             | Distinct.         | Slight.         | Faintly vegetable.                  | Faintly vegetable.                  | .0122    | .0108       | .1359            | 4                               | 58                             |
| Aug. 29             | Dist'ct, green.   | Cons., brown.   | De'd'ly v'g'ble & disag'ble.        | Stro'gly vegetable, grassy.         | .0000    | .0638       | .3397            | 460                             | 200                            |
| Aug. 29             | V. slight, milky. | V. slight.      | Decidedly vegetable & unpleasant.   | De'd'ly vegetable and disagreeable. | .0206    | .0212       | .1659            | 80                              | 38                             |
| Sept. 6             | De'ded, green.    | Slight, yellow. | Dist'ly v'g'ble & disag'ble.        | De'd'd, sw'ish and grassy.          | .0000    | .0258       | .2925            | 336                             | 0                              |
| Sept. 6             | Distinct, yellow. | Slight.         | Decided, disagreeable.              | Decided, disagreeable.              | .0096    | .0226       | .1560            | 30                              | 28                             |
| Sept. 13            | De'ded, green.    | Slight, yellow. | Distinctly vegetable.               | Distinctly vegetable.               | .0000    | .0898       | .2184            | 925                             | 0                              |
| Sept. 13            | Slight, milky.    | Slight.         | Decided, vegetable.                 | Decided, disagreeable.              | .0000    | .0224       | .1950            | 11                              | 48                             |
| Sept. 20            | De'ded, green.    | Slight, yellow. | De'd'ly v'g'ble and grassy.         | De'ded, sweet, grassy.              | .0000    | .0670       | .2706            | 508                             | 0                              |
| Sept. 20            | Decided, green.   | Slight.         | Decided, disagreeable.              | Decided, disagreeable.              | .0098    | .0516       | .3649            | 63                              | 480                            |
| Oct. 4              | Dist'ct, green.   | Cons., green.   | Distinctly unpleasant.              | De'd'ly v'g'ble and grassy.         | .0000    | .0574       | .1463            | 966                             | 136                            |
| Oct. 4              | Slight, milky.    | V. slight.      | Decidedly unpleasant.               | Decidedly grassy and unpleasant.    | .0014    | .0176       | .1155            | 38                              | 30                             |
| Oct. 11             | Dist'ct, green.   | Cons.           | De'd'ly v'g'ble & disag'ble.        | De'd'ly v'g'ble and grassy.         | .0010    | .0442       | .1863            | 1,748                           | 72                             |
| Oct. 11             | Slight, milky.    | V. slight.      | Dist'ly vegetable and disagreeable. | Dist'ly vegetable and grassy.       | .0004    | .0112       | .1174            | 101                             | 13                             |
| Oct. 18             | Dist'ct, milky.   | Slight.         | Faint'ly v'g'ble and grassy.        | Str'gly v'g'ble and grassy.         | .0022    | .0286       | .1368            | 800                             | 6                              |
| Oct. 18             | None.             | None.           | Distinctly vegetable.               | Very faintly vegetable.             | .0000    | .0056       | .0912            | 5                               | 1                              |
| Av.....             |                   |                 |                                     |                                     | .0016    | .0520       | .2351            | 1,008                           | 70                             |
| Av.....             |                   |                 |                                     |                                     | .0000    | .0200       | .1653            | 41                              | 77                             |

**NANTUCKET.***Chemical Examination of Water from Wannacomet Pond, Nantucket.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. |           |
|---------|---------------------|------------------|-------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.       | Sediment.         | Color. | Total.                  | Loss on ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. | Oxygen Consumed. | Hardness. |
|         |                     |                  |                   |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
|         | 1893.               |                  |                   |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 10801   | Aug. 14             | Decided, green.  | Cons., rusty.     | 0.70   | 7.20                    | 2.25              | .0110    | .0526       | .0272      | .0254      | 2.04      | .0000       | .0000     | .2607            | 1.7       |
| 10874   | Aug. 22             | Decided, green.  | Slight, yellow.   | 0.45   | 7.40                    | 2.90              | .0002    | .0590       | .0234      | .0356      | 2.23      | .0000       | .0000     | .2646            | 1.6       |
| 10922   | Aug. 29             | Distinct, green. | Cons., brown.     | 0.30   | 6.50                    | 2.00              | .0000    | .0638       | .0190      | .0448      | 2.16      | .0000       | .0000     | .3397            | 1.4       |
| 10982   | Sept. 6             | Decided, green.  | Slight, yellow.   | 0.18   | 7.00                    | 1.50              | .0000    | .0258       | .0250      | .0008      | 1.99      | .0000       | .0000     | .2925            | 1.6       |
| 11025   | Sept. 13            | Decided, green.  | Slight, yellow.   | 0.25   | 8.45                    | 3.05              | .0000    | .0608       | .0240      | .0458      | 2.00      | .0070       | .0001     | .2184            | 1.7       |
| 11070   | Sept. 20            | Decided, green.  | Slight, yellow.   | 0.30   | 7.60                    | 2.70              | .0000    | .0670       | .0332      | .0338      | 2.00      | .0050       | .0000     | .2706            | 1.6       |
| 11117   | Sept. 28            | Distinct, green. | Cons., green.     | 0.20   | 7.05                    | 1.70              | .0000    | .0674       | .0250      | .0424      | -         | .0030       | .0000     | .2233            | 1.6       |
| 11146   | Oct. 4              | Distinct, green. | Cons., green.     | 0.25   | 6.95                    | 2.10              | .0000    | .0574       | .0228      | .0346      | 2.00      | .0000       | .0000     | .1463            | 1.5       |
| 11176   | Oct. 11             | Distinct, green. | Cons.             | 0.10   | 6.80                    | 1.95              | .0010    | .0442       | .0170      | .0272      | -         | .0000       | .0000     | .1803            | 1.7       |
| 11228   | Oct. 18             | Distinct, green. | Slight.           | 0.10   | 7.05                    | 1.85              | .0022    | .0286       | .0134      | .0152      | 2.22      | .0050       | .0000     | .1368            | 1.6       |
| 11253   | Oct. 25             | Distinct, green. | V. slight, green. | 0.00   | -                       | -                 | -        | -           | -          | -          | -         | -           | -         | -                | -         |
| 11315   | Nov. 8              | Slight.          | Cons., yellow.    | 0.02   | 5.85                    | 1.10              | .0016    | .0170       | .0126      | .0044      | 2.01      | .0050       | .0000     | .1680            | 1.3       |
| 11465   | Dec. 6              | Slight.          | Slight, yellow.   | 0.02   | 6.20                    | 1.20              | .0000    | .0108       | .0072      | .0036      | 2.13      | .0050       | .0000     | .0936            | 1.6       |
| Av.,    | .....               | .....            | .....             | 0.22   | 7.00                    | 2.02              | .0013    | .0469       | .0208      | .0261      | 2.08      | .0025       | .0000     | .2167            | 1.6       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |      |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|------|-------|-------|-------|-----|
| - | 1887* | - | - | 0.05 | 6.72 | 1.20 | .0002 | .0175 | -     | -     | 2.20 | .0020 | -     | -     | -   |
| - | 1888† | - | - | 0.05 | 5.98 | 0.98 | .0002 | .0153 | -     | -     | 2.11 | .0048 | .0002 | -     | -   |
| - | 1889‡ | - | - | 0.10 | -    | -    | .0031 | .0416 | .0269 | .0147 | 1.99 | .0035 | .0001 | -     | -   |
| - | 1890§ | - | - | 0.00 | -    | -    | .0006 | .0188 | .0127 | .0061 | 1.95 | .0025 | .0000 | -     | -   |
| - | 1891  | - | - | 0.22 | 7.54 | 2.33 | .0112 | .0585 | .0337 | .0271 | 1.86 | .0076 | .0001 | -     | 1.4 |
| - | 1892¶ | - | - | 0.03 | 6.84 | 1.68 | .0004 | .0136 | .0111 | .0025 | 2.22 | .0033 | .0000 | -     | 1.6 |
| - | 1893  | - | - | 0.22 | 7.00 | 2.02 | .0013 | .0469 | .0208 | .0261 | 2.08 | .0025 | .0000 | .2167 | 1.6 |

\* July to November.

† February to May

‡ September to November.

§ March and April.

|| August to December.

¶ May to October.

NOTE to Analyses of 1893; Iron, .0307. Odor, generally distinctly vegetable and disagreeable, often becoming stronger on heating. — The samples were collected from the pond.

## NANTUCKET.

*Microscopical Examination of Water from Wannacomel Pond, Nantucket.*

[Number of organisms per cubic centimeter.]

|                            | 1893. |       |       |       |       |       |       |       |       |       |       |       |       |
|----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                            | Aug.  | Aug.  | Aug.  | Sept. | Sept. | Sept. | Sept. | Oct.  | Oct.  | Oct.  | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .  | 16    | 24    | 31    | 9     | 15    | 22    | 30    | 6     | 12    | 21    | 27    | 11    | 8     |
| Number of sample, . . .    | 10801 | 10874 | 10922 | 10982 | 11025 | 11070 | 11117 | 11146 | 11176 | 11228 | 11253 | 11315 | 11465 |
| PLANTS.                    |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, Synedra, . . . | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | pr.   | 400   |
| Cyanophyceæ, . . .         | 2,224 | 1,100 | 467   | 336   | 925   | 508   | 176   | 968   | 1,748 | 800   | 448   | 5     | 0     |
| Anabaena, . . .            | 2,160 | 760   | 200   | 228   | 860   | 356   | 176   | 968   | 1,748 | 744   | 440   | 5     | 0     |
| Anabaena spores, . . .     | 64    | 340   | 260   | 108   | 65    | 152   | 0     | 0     | 0     | 56    | 9     | 0     | 0     |
| Microcystis, . . .         | 0     | 0     | 7     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Algae, . . .               | 16    | 2     | 9     | 1     | 25    | 10    | 0     | 0     | 0     | 1     | 9     | 36    | 14    |
| Pandorina, . . .           | 10    | 0     | 1     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 7     | 0     | 0     |
| Protococcus, . . .         | 0     | 0     | 3     | 0     | 25    | 10    | 0     | 0     | 0     | 0     | 0     | 1     | 12    |
| Scenedesmus, . . .         | 4     | 2     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 34    | 2     |
| Staurostrum, . . .         | 2     | 0     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 1     | 0     |
| Fungi, Crenothrix, . . .   | 56    | 0     | 0     | 0     | 0     | 0     | 2     | 2     | 0     | 0     | 0     | 1     | 0     |
| ANIMALS.                   |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . .           | 8     | 9     | 20    | 2     | 0     | 0     | 0     | 2     | 10    | 3     | 21    | 354   | 16    |
| Cryptomonas, . . .         | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 7     |
| Dinobryon, . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 10    | 80    | 0     |
| Dinobryon cases, . . .     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 260   | 4     |
| Euglena, . . .             | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | pr.   | 0     |
| Glenodinium, . . .         | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     |
| Monas, . . .               | 4     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 8     | 0     | 0     | 0     | 0     |
| Peridinium, . . .          | 2     | 9     | 20    | 2     | 0     | 0     | 0     | 2     | 2     | 3     | 6     | 34    | 3     |
| Vorticella, . . .          | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 5     | 0     | 0     |
| Vermes, . . .              | 8     | 4     | 9     | 4     | 0     | 0     | 0     | 4     | 0     | 7     | 16    | 6     | 3     |
| Anurea, . . .              | 4     | 1     | 5     | 3     | 0     | 0     | 0     | 2     | 0     | 6     | 15    | 5     | 0     |
| Monocerca, . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     |
| Polyarthra, . . .          | 2     | 2     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 3     |
| Rotatorian ova, . . .      | 2     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 1     | 0     | 0     |
| Rotifer, . . .             | 0     | 1     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Crustacea, . . .           | .08   | 0     | .02   | .01   | .10   | .07   | 0     | 0     | 0     | 0     | 0     | .01   | .04   |
| Cyclops, . . .             | 0     | 0     | 0     | 0     | 0     | .02   | 0     | 0     | 0     | 0     | 0     | .01   | .04   |
| Daphnia, . . .             | .08   | 0     | .02   | .01   | .10   | .05   | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Miscellaneous, . . .       | 144   | 76    | 200   | 0     | .10   | 0     | 208   | 136   | 72    | 6     | 0     | 2     | 5     |
| Acarina, . . .             | 0     | .01   | 0     | 0     | .10   | 0     | 0     | .04   | .04   | 0     | 0     | 0     | 0     |
| Zoöglæa, . . .             | 144   | 76    | 200   | 0     | 0     | 0     | 208   | 136   | 72    | 6     | 0     | 2     | 5     |
| TOTAL, . . .               | 2,456 | 1,191 | 705   | 343   | 950   | 518   | 386   | 1,112 | 1,830 | 817   | 497   | 404   | 438   |



## NANTUCKET.

*Chemical Examination of Water from Wannacomet Pond after Filtration.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.        | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 10802   | 1893.<br>Aug. 14    | None.             | None.      | 0.15   | 6.50                    | .0000    | .0168       | 1.98      | .0000       | .0000     | .1461            | 1.6       | .0125 |
| 10875   | Aug. 22             | Distinct.         | Slight.    | 0.08   | 7.25                    | .0122    | .0108       | 2.04      | .0100       | .0001     | .1359            | 2.1       | .0090 |
| 10923   | Aug. 29             | V. slight, milky. | V. slight. | 0.10   | 6.50                    | .0206    | .0212       | 2.14      | .0020       | .0001     | .1659            | 1.6       | .0080 |
| 10983   | Sept. 6             | Distinct, yellow. | Slight.    | 0.15   | 8.40                    | .0096    | .0226       | 2.00      | .0050       | .0001     | .1560            | 2.3       | .0140 |
| 11026   | Sept. 13            | Slight, milky.    | Slight.    | 0.05   | 7.15                    | .0000    | .0224       | 2.04      | .0070       | .0001     | .1950            | 2.3       | .0160 |
| 11071   | Sept. 20            | Decided, green.   | Slight.    | 0.60   | 8.75                    | .0098    | .0516       | 1.99      | .0030       | .0001     | .3649            | 2.5       | .0300 |
| 11147   | Oct. 4              | Slight, milky.    | V. slight. | 0.15   | 6.35                    | .0014    | .0176       | 2.00      | .0030       | .0003     | .1155            | 1.5       | .0135 |
| 11177   | Oct. 11             | Slight, milky.    | V. slight. | 0.05   | 6.25                    | .0004    | .0112       | -         | .0120       | .0000     | .1174            | 1.6       | .0070 |
| 11229   | Oct. 18             | None.             | None.      | 0.02   | 7.20                    | .0000    | .0056       | 2.18      | .0100       | .0001     | .0912            | 1.3       | .0075 |
| Av...   | .....               | .....             | .....      | 0.15   | 7.15                    | .0060    | .0200       | 2.05      | .0058       | .0001     | .1653            | 1.9       | .0131 |

Odor, generally distinctly vegetable and unpleasant or disagreeable. — Nos. 10923 and 10983 were collected directly from the filter; the remaining samples, from a faucet at the pumping station while drawing water from the filter.

*Microscopical Examination of Water from Wannacomet Pond after Filtration.*

[Number of organisms per cubic centimeter.]

|                               | 1893. |       |       |       |       |       |       |       |       |      |
|-------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|
|                               | Aug.  | Aug.  | Aug.  | Sept. | Sept. | Sept. | Sept. | Oct.  | Oct.  | Oct. |
| Day of examination, . . .     | 16    | 24    | 31    | 9     | 15    | 22    | 6     | 12    | 21    |      |
| Number of sample, . . .       | 10802 | 10875 | 10923 | 10983 | 11026 | 11071 | 11147 | 11177 | 11229 |      |
| PLANTS.                       |       |       |       |       |       |       |       |       |       |      |
| Cyanophycæ, . . . . .         | 36    | 4     | 80    | 30    | 11    | 63    | 38    | 101   | 5     |      |
| Anabæna, . . . . .            | 36    | 3     | 80    | 28    | 11    | 60    | 38    | 101   | 5     |      |
| Anabæna spores, . . .         | 0     | 1     | 0     | 2     | 0     | 3     | 0     | 0     | 0     |      |
| Algæ, . . . . .               | 10    | 18    | 0     | 1     | 5     | 0     | 0     | 0     | 0     |      |
| Pandorina, . . . . .          | 10    | 18    | 0     | 1     | 0     | 0     | 0     | 0     | 0     |      |
| Protococcus, . . . . .        | 0     | 0     | 0     | 0     | 5     | 0     | 0     | 0     | 0     |      |
| Miscellaneous, Zoöglæa, . . . | 1     | 58    | 38    | 28    | 48    | 480   | 30    | 13    | 1     |      |
| TOTAL, . . . . .              | 47    | 80    | 118   | 59    | 64    | 543   | 68    | 114   | 6     |      |

## NATICK.

## WATER SUPPLY OF NATICK.

*Chemical Examination of Water from Dug Pond, Natick.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|--------------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.         | Sediment. | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                    |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 9845    | 1893.<br>Jan. 3     | Slight.            | Slight.   | 0.05   | 5.35                            | 0.95                 | .0138    | .0178       | .0144      | .0034           | .75       | .0050          | .0000     | .1715            | 2.5       |
| 9975    | Feb. 6              | V. slight.         | Slight.   | 0.04   | 5.45                            | 1.20                 | .0182    | .0190       | .0170      | .0020           | .76       | .0100          | .0001     | .2263            | 2.5       |
| 10075   | Mar. 2              | V. slight.         | Slight.   | 0.08   | 5.60                            | 1.75                 | .0150    | .0158       | .0134      | .0024           | .68       | .0180          | .0001     | .1908            | 2.1       |
| 10206   | Apr. 3              | Slight,<br>clayey. | Slight.   | 0.08   | 4.80                            | 1.00                 | .0098    | .0148       | .0124      | .0024           | .60       | .0450          | .0004     | .2190            | 1.8       |
| 10348   | May 2               | Slight.            | Slight.   | 0.08   | 5.15                            | 1.05                 | .0016    | .0178       | .0146      | .0032           | .66       | .0480          | .0003     | .1971            | 1.9       |
| 10471   | June 1              | Slight.            | Slight.   | 0.10   | 5.35                            | 1.45                 | .0034    | .0160       | .0136      | .0024           | .70       | .0500          | .0005     | .3037            | 1.9       |
| 10598   | July 5              | Distinct.          | Slight.   | 0.05   | 5.35                            | 1.80                 | .0020    | .0254       | .0220      | .0034           | .71       | .0300          | .0005     | .3397            | 1.9       |
| 10725   | Aug. 3              | Distinct.          | Slight.   | 0.15   | 5.65                            | 1.65                 | .0010    | .0194       | .0158      | .0036           | .74       | .0150          | .0001     | .1561            | 2.1       |
| 10945   | Sept. 1             | Distinct.          | Slight.   | 0.08   | 5.40                            | 1.85                 | .0000    | .0220       | .0166      | .0054           | .70       | .0000          | .0001     | .2646            | 2.1       |
| 11130   | Oct. 2              | Distinct.          | Slight.   | 0.05   | 5.30                            | 1.55                 | .0006    | .0238       | .0192      | .0046           | .72       | .0000          | .0000     | .2233            | 2.3       |
| 11281   | Nov. 1              | Slight.            | Cona.     | 0.12   | 5.05                            | 1.30                 | .0038    | .0220       | .0164      | .0056           | .73       | .0030          | .0005     | .3080            | 2.1       |
| 11442   | Dec. 4              | V. slight.         | Slight.   | 0.12   | 4.95                            | 1.10                 | .0054    | .0168       | .0144      | .0024           | .72       | .0080          | .0004     | .2106            | 2.2       |
| Av..    | .....               | .....              | .....     | 0.08   | 5.28                            | 1.39                 | .0062    | .0192       | .0158      | .0034           | .71       | .0193          | .0003     | .2345            | 2.1       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 0.14 | 5.25 | 1.21 | .0039 | .0215 | -     | -     | .70 | .0050 | -     | -     | -   |
| - | 1888  | - | - | 0.13 | 5.24 | 1.09 | .0070 | .0228 | -     | -     | .66 | .0197 | .0003 | -     | -   |
| - | 1889  | - | - | 0.16 | 5.51 | 1.22 | .0044 | .0242 | .0196 | .0046 | .71 | .0289 | .0004 | -     | -   |
| - | 1890  | - | - | 0.14 | 5.85 | 1.36 | .0027 | .0199 | .0166 | .0033 | .72 | .0227 | .0002 | -     | 2.7 |
| - | 1891  | - | - | 0.09 | 5.71 | 1.45 | .0085 | .0207 | .0167 | .0040 | .69 | .0326 | .0003 | -     | 2.4 |
| - | 1892  | - | - | 0.06 | 5.38 | 1.24 | .0068 | .0173 | .0135 | .0038 | .72 | .0323 | .0001 | -     | 2.4 |
| - | 1893  | - | - | 0.08 | 5.28 | 1.39 | .0062 | .0192 | .0158 | .0034 | .71 | .0193 | .0003 | .2345 | 2.1 |

\* June to December.

NOTE to analyses of 1893; Iron, .0074. Odor, generally distinctly vegetable and unpleasant, often disagreeable. — The samples were collected from a faucet at the pumping station.

## NATICK.

*Microscopical Examination of Water from Dug Pond, Natick.*

[Number of organisms per cubic centimeter.]

|                            | 1893. |      |       |       |       |       |       |       |       |       |       |       |
|----------------------------|-------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                            | Jan.  | Feb. | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .  | 5     | 7    | 3     | 4     | 3     | 2     | 7     | 4     | 2     | 3     | 3     | 6     |
| Number of sample, . . .    | 9845  | 9975 | 10075 | 10206 | 10348 | 10471 | 10598 | 10725 | 10945 | 11130 | 11281 | 11442 |
| <b>PLANTS.</b>             |       |      |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .          | 494   | 3    | 9     | 30    | 778   | 13    | 105   | 145   | 39    | 10    | 432   | 1,465 |
| Asterionella, . . .        | 68    | 0    | 0     | pr.   | 58    | 0     | 0     | 0     | 0     | 5     | 36    | 720   |
| Cyclotella, . . .          | 338   | 3    | 0     | 1     | 78    | 7     | 68    | 144   | 1     | 0     | 24    | 80    |
| Melosira, . . .            | 48    | 0    | 9     | 26    | 600   | 5     | 29    | 0     | 36    | 0     | 360   | 640   |
| Synedra, . . .             | 40    | 0    | pr.   | 3     | 42    | 0     | 0     | 1     | 2     | 1     | 0     | 2     |
| Tabellaria, . . .          | 0     | 0    | 0     | 0     | 0     | 1     | 8     | 0     | 0     | 4     | 12    | 23    |
| Cyanophyceæ, . . .         | pr.   | 0    | 0     | 0     | 0     | 0     | 0     | 3     | 11    | 0     | 2     | 0     |
| Clathrocystis, . . .       | pr.   | 0    | 0     | 0     | 0     | 0     | 0     | 3     | 4     | 0     | 0     | 0     |
| Microcystis, . . .         | 0     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 7     | 0     | 2     | 0     |
| Algæ, . . .                | 24    | 0    | pr.   | pr.   | 50    | 10    | 137   | 12    | 21    | 14    | 133   | 24    |
| Chlorococcus, . . .        | 2     | 0    | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 14    | 12    | 0     |
| Closterium, . . .          | 3     | 0    | pr.   | pr.   | 0     | 0     | 1     | 1     | 1     | 0     | 14    | 24    |
| Glaucocystis, . . .        | 0     | 0    | 0     | 0     | 0     | 0     | 36    | 0     | 2     | 0     | 7     | 0     |
| Protococcus, . . .         | 14    | 0    | 0     | 0     | 4     | 10    | 100   | 10    | 16    | 0     | 100   | 0     |
| Raphidium, . . .           | 5     | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     |
| Zoëspores, . . .           | 0     | 0    | 0     | 0     | 46    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Fungi, Crenothrix, . . .   | 1     | 0    | pr.   | 2     | 0     | 0     | 0     | 0     | 0     | 3     | pr.   | 0     |
| <b>ANIMALS.</b>            |       |      |       |       |       |       |       |       |       |       |       |       |
| Rhizopoda, Diffugia, . . . | 1     | 0    | pr.   | 0     | 0     | pr.   | 0     | 0     | 0     | 0     | 0     | 0     |
| Infusoria, . . .           | pr.   | pr.  | 0     | pr.   | 4     | pr.   | 53    | 0     | 3     | 0     | 15    | 4     |
| Dinobryon cases, . . .     | pr.   | 0    | 0     | 0     | 1     | 0     | 52    | 0     | 0     | 0     | 14    | 3     |
| Monas, . . .               | 0     | 0    | 0     | 0     | 0     | 0     | 1     | 0     | 1     | 0     | pr.   | 0     |
| Peridinium, . . .          | 0     | pr.  | 0     | pr.   | 2     | 0     | pr.   | 0     | 2     | 0     | 0     | 1     |
| Trachelomonas, . . .       | pr.   | pr.  | 0     | 0     | pr.   | pr.   | pr.   | 0     | 0     | 0     | 1     | 0     |
| Vorticella, . . .          | pr.   | 0    | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Vermes, Anurea, . . .      | pr.   | pr.  | 0     | 0     | 0     | 0     | 0     | 1     | 5     | 0     | 0     | 0     |
| <b>Miscellaneous.</b>      |       |      |       |       |       |       |       |       |       |       |       |       |
| Acarina, . . .             | 0     | 0    | 0     | 0     | .01   | 0     | 0     | 0     | 0     | .32   | .01   | 0     |
| Zoöglæa, . . .             | 18    | 0    | 12    | 0     | 2     | 0     | 3     | 28    | 10    | 98    | 9     | 2     |
| TOTAL, . . .               | 538   | 3    | 21    | 32    | 834   | 23    | 298   | 180   | 89    | 125   | 591   | 1,495 |

## NATICK.

*Table showing Heights of Water in Dug Pond on Dates when Samples of Water were collected for Analysis.*

NOTE. — High-water mark is 13.0 feet.

| DATE. — 1892. |   |   |   | Height of Water. | DATE. — 1892. |   |   |   | Height of Water. |
|---------------|---|---|---|------------------|---------------|---|---|---|------------------|
|               |   |   |   | Feet.            |               |   |   |   | Feet.            |
| Jan. 3,       | . | . | . | 8.75             | July 5,       | . | . | . | 11.68            |
| Feb. 6,       | . | . | . | 8.33             | Aug. 3,       | . | . | . | 10.25            |
| Mar. 2,       | . | . | . | 10.83            | Sept. 1,      | . | . | . | 9.75             |
| April 3,      | . | . | . | 13.29            | Oct. 2,       | . | . | . | 8.92             |
| May 5,        | . | . | . | 14.00            | Nov. 1,       | . | . | . | 8.50             |
| June 1,       | . | . | . | 13.00            | Dec. 4,       | . | . | . | 8.33             |

## WATER SUPPLY OF NEEDHAM.

*Chemical Examination of Water from the Well of the Needham Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 10035   | 1893.<br>Feb. 20    | None.       | None.     | 0.0    | 4.80                    | .0000    | .0012       | .68       | .1300       | .0000     | .0277            | 2.5       | .0000 |
| 10435   | May 23              | None.       | None.     | 0.0    | 5.90                    | .0000    | .0002       | .73       | .2000       | .0000     | .0450            | 1.9       | .0000 |
| 10865   | Aug. 21             | None.       | None.     | 0.0    | 5.60                    | .0000    | .0000       | .56       | .0750       | .0000     | .0735            | 1.6       | .0000 |
| 11329   | Nov. 14             | None.       | None.     | 0.0    | 5.10                    | .0000    | .0018       | .58       | .1000       | .0000     | .0664            | 1.8       | .0000 |
| 11503   | Dec. 18             | None.       | None.     | 0.0    | 5.00                    | .0000    | .0004       | .50       | .1100       | .0000     | .0480            | 1.6       | .0000 |
| Av...   | .....               | .....       | .....     | 0.0    | 5.28                    | .0000    | .0007       | .63       | .1230       | .0000     | .0522            | 1.9       | .0000 |

Odor, none. — Nos. 10435 and 11503 were collected from faucets in the village; the remaining samples either directly from the well or from a faucet at the pumping station while pumping.

*Microscopical Examination.*

An insignificant number of organisms was found in all but one of these samples.

## NEW BEDFORD.

## WATER SUPPLY OF NEW BEDFORD.

*Chemical Examination of Water from the Conduit of the New Bedford Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 9950    | 1893.<br>Jan. 30    | None.       | V. slight.        | 1.60   | 6.80                            | 3.00                 | .0055    | .0286       | .0236      | .0050           | .62       | .0070          | .0001     | 1.4965           | 1.8       |
| 10063   | Mar. 1              | V. slight.  | Slight.           | 1.25   | 4.80                            | 2.30                 | .0008    | .0184       | .0180      | .0024           | .48       | .0070          | .0001     | 1.1268           | 1.7       |
| 10185   | Mar. 29             | V. slight.  | Slight.           | 1.30   | 4.25                            | 2.30                 | .0004    | .0146       | .0130      | .0016           | .38       | .0150          | .0001     | 0.8468           | 0.8       |
| 10438   | May 23              | V. slight.  | Cons.             | 2.10   | 4.65                            | 2.15                 | .0012    | .0236       | .0224      | .0012           | .37       | .0030          | .0000     | 1.3237           | 0.3       |
| 10563   | June 26             | V. slight.  | Slight,<br>rusty. | 1.80   | 4.55                            | 2.00                 | .0012    | .0232       | .0200      | .0032           | .48       | .0070          | .0001     | 1.2442           | 0.6       |
| 10696   | July 25             | V. slight.  | Slight.           | 2.00   | 4.85                            | 2.60                 | .0020    | .0268       | .0226      | .0042           | .49       | .0030          | .0002     | 1.0700           | 0.9       |
| 10896   | Aug. 28             | V. slight.  | Cons.,<br>brown.  | 1.30   | 3.95                            | 1.70                 | .0004    | .0170       | -          | -               | .49       | .0000          | .0002     | 1.0428           | 0.3       |
| 11115   | Sept. 28            | V. slight.  | Slight.           | 0.85   | 4.15                            | 1.90                 | .0000    | .0254       | .0180      | .0074           | .50       | .0030          | .0000     | 0.6776           | 1.3       |
| 11235   | Oct. 23             | V. slight.  | Slight.           | 0.75   | 6.65                            | 3.35                 | .0000    | .0220       | .0184      | .0036           | .54       | .0030          | .0001     | 0.5548           | 0.6       |
| 11393   | Nov. 27             | V. slight.  | V. slight.        | 0.90   | 4.95                            | *1.85                | .0088    | .0210       | .0166      | .0050           | .61       | .0030          | .0002     | 1.0277           | 1.6       |
| 11505   | Dec. 17             | V. slight.  | Slight.           | 1.00   | 6.00                            | 2.80                 | .0040    | .0196       | .0180      | .0016           | .67       | .0050          | .0001     | 1.0732           | 1.4       |
| Av.     | .....               | .....       | .....             | 1.35   | 5.05                            | 2.36                 | .0022    | *.0224      | .0189      | .0035           | .51       | .0051          | .0001     | 1.0440           | 1.0       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |        |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|--------|-----|
| - | 1887† | - | - | 1.37 | 5.16 | 1.95 | .0021 | .0206 | -     | -     | .56 | .0137 | -     | -      | -   |
| - | 1888  | - | - | 1.48 | 5.19 | 2.32 | .0014 | .0254 | -     | -     | .53 | .0183 | .0001 | -      | -   |
| - | 1889  | - | - | 1.51 | 3.96 | 1.74 | .0014 | .0241 | .0206 | .0035 | .50 | .0103 | .0001 | -      | -   |
| - | 1890  | - | - | 1.48 | 5.01 | 2.41 | .0013 | .0232 | .0196 | .0037 | .45 | .0125 | .0001 | -      | 1.2 |
| - | 1891  | - | - | 0.95 | 3.90 | 1.81 | .0005 | .0197 | .0171 | .0026 | .42 | .0103 | .0000 | -      | 0.8 |
| - | 1892  | - | - | 1.10 | 4.87 | 2.24 | .0006 | .0227 | .0194 | .0033 | .52 | .0108 | .0001 | -      | 1.0 |
| - | 1893  | - | - | 1.35 | 5.05 | 2.36 | .0022 | .0224 | .0189 | .0035 | .51 | .0051 | .0001 | 1.0440 | 1.0 |

\* Exclusive of No. 10896.

† June to December.

NOTE to Analyses of 1893; Iron, .0223. Odor, vegetable and grassy or sweetish. — The samples were collected from the conduit at its entrance to the receiving reservoir. Water from Little Quittacas Pond was drawn into the storage reservoir from July 23 to about Oct. 1, 1893.

## NEW BEDFORD.

*Microscopical Examination of Water from the Conduit of the New Bedford Water Works.*

[Number of organisms per cubic centimeter.]

|                               | 1893. |       |       |       |       |       |       |       |       |       |       |
|-------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                               | Jan.  | Mar.  | Mar.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .     | 31    | 2     | 30    | 24    | 27    | 26    | 29    | 30    | 24    | 28    | 19    |
| Number of sample, . . .       | 9950  | 10063 | 10185 | 10438 | 10563 | 10696 | 10896 | 11115 | 11235 | 11393 | 11505 |
| PLANTS.                       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .             | 0     | 0     | 3     | 28    | 1     | 1     | 1     | 0     | 1     | 1     | 2     |
| Asterionella, . . .           | 0     | 0     | 1     | 8     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Synedra, . . .                | 0     | 0     | 2     | 20    | 1     | 1     | 1     | 0     | 1     | 1     | 2     |
| Cyanophyceæ, . . .            | 0     | 0     | 0     | 0     | 0     | 110   | 16    | 0     | 0     | 0     | 0     |
| Clathrocystis, . . .          | 0     | 0     | 0     | 0     | 0     | 6     | 0     | 0     | 0     | 0     | 0     |
| Merismopedia, . . .           | 0     | 0     | 0     | 0     | 0     | 104   | 16    | 0     | 0     | 0     | 0     |
| Algæ, Protococcus, . . .      | 0     | pr.   | 0     | 0     | 0     | 58    | 12    | 0     | 0     | 0     | 0     |
| Fungi, Crengothrix, . . .     | pr.   | pr.   | 1     | 16    | 3     | 2     | 28    | 0     | 3     | 0     | 0     |
| ANIMALS.                      |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . .              | 5     | pr.   | 10    | 1     | 0     | 0     | 2     | 0     | 0     | pr.   | 0     |
| Dinobryon, . . .              | 5     | 0     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, . . .        | pr.   | pr.   | pr.   | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Peridinium, . . .             | pr.   | pr.   | 7     | 0     | 0     | 0     | 1     | 0     | 0     | pr.   | 0     |
| Trachelomonas, . . .          | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 0     | pr.   | 0     |
| Miscellaneous, Zoöglæa, . . . | 125   | 44    | 20    | 28    | 24    | 36    | 92    | 28    | 8     | 2     | 13    |
| TOTAL, . . .                  | 131   | 44    | 34    | 73    | 28    | 207   | 151   | 28    | 12    | 3     | 15    |

*Chemical Examination of Water from Little Quittacas Pond, Lakeville.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1893.   |                     |             |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 10195   | Mar. 31             | Slight.     | Cons.      | 0.10   | 2.55                            | 0.80                 | .0064    | .0136       | .0120      | .0016           | .46       | .0030          | .0001     | .2774            | 0.6       |
| 10659   | July 12             | V. slight.  | V. slight. | 0.10   | 2.75                            | 1.30                 | .0000    | .0162       | .0120      | .0042           | .48       | .0000          | .0000     | .2701            | 0.5       |
| 10706   | July 26             | V. slight.  | Slight.    | 0.12   | 3.90                            | 1.65                 | .0008    | .0182       | .0140      | .0042           | .43       | .0030          | .0000     | .3330            | 0.5       |
| 10772   | Aug. 9              | Distinct.   | Slight.    | 0.12   | 3.05                            | 1.40                 | .0004    | .0160       | .0126      | .0034           | .48       | .0000          | .0000     | .2902            | 0.5       |
| 10946   | Aug. 31             | Slight.     | Slight.    | 0.10   | 2.90                            | 1.05                 | .0000    | .0160       | .0130      | .0030           | .50       | .0050          | .0000     | .3397            | 0.7       |
|         |                     |             | brown.     |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 10934   | Sept. 6             | Slight.     | Slight.    | 0.10   | 2.75                            | 1.10                 | .0000    | .0176       | .0162      | .0024           | .47       | .0000          | .0000     | .2652            | 0.3       |
| 11116   | Sept. 28            | V. slight.  | Slight.    | 0.10   | 3.20                            | 1.10                 | .0000    | .0148       | .0124      | .0024           | .48       | .0050          | .0000     | .2541            | 0.6       |
| 11506   | Dec. 17             | V. slight.  | Slight.    | 0.15   | 3.25                            | 1.55                 | .0006    | .0148       | .0124      | .0024           | .49       | .0030          | .0000     | .2956            | 0.6       |
| Av.*    | .....               | .....       | .....      | 0.11   | 3.02                            | 1.23                 | .0015    | .0156       | .0128      | .0028           | .48       | .0025          | .0000     | .2904            | 0.6       |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

Iron, .0032. Odor of No. 10706, distinctly vegetable; of No. 11506, faintly vegetable; of the remaining samples, none. — The samples were collected from the pond generally about five feet beneath the surface.

## NEW BEDFORD.

*Microscopical Examination of Water from Little Quittacas Pond, Lakeville.*

[Number of organisms per cubic centimeter.]

|                                    | 1892.  |       |       |       |       |       |       |       |
|------------------------------------|--------|-------|-------|-------|-------|-------|-------|-------|
|                                    | April. | July. | July. | Aug.  | Sept. | Sept. | Sept. | Dec.  |
| Day of examination, . . .          | 4      | 15    | 28    | 11    | 2     | 9     | 30    | 19    |
| Number of sample, . . .            | 10195  | 10659 | 10706 | 10772 | 10946 | 10984 | 11116 | 11506 |
| <b>PLANTS.</b>                     |        |       |       |       |       |       |       |       |
| Diatomaceæ, . . . .                | 203    | 14    | 12    | 26    | 26    | 21    | 0     | 13    |
| Asterionella, . . . .              | 3      | 0     | 0     | 0     | 0     | 0     | 0     | 2     |
| Cyclotella, . . . .                | 5      | 14    | 10    | 24    | 20    | 20    | 0     | 9     |
| Melosira, . . . .                  | 2      | 0     | 2     | 0     | 3     | 0     | 0     | 0     |
| Synedra, . . . .                   | 188    | 0     | 0     | 0     | 3     | 1     | 0     | 2     |
| Tabellaria, . . . .                | 5      | 0     | 0     | 2     | 0     | pr.   | 0     | 0     |
| Cyanophyceæ, Merismopedia, . . . . | 0      | 0     | 0     | 5     | 0     | 0     | 0     | 8     |
| Algæ, Protococcus, . . . .         | 23     | 8     | 11    | 0     | 0     | 0     | 0     | 0     |
| <b>ANIMALS.</b>                    |        |       |       |       |       |       |       |       |
| Infusoria, . . . .                 | 450    | 2     | 0     | 0     | 0     | 1     | 0     | 0     |
| Dinobryon cases, . . . .           | 450    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Peridinium, . . . .                | 0      | 2     | 0     | 0     | 0     | 0     | 0     | 0     |
| Trachelomonas, . . . .             | 0      | 0     | 0     | 0     | 0     | 1     | 0     | 0     |
| Miscellaneous, Zoëglæa, . . . .    | 182    | 22    | 36    | 32    | 1,800 | 42    | 46    | 2     |
| TOTAL, . . . .                     | 858    | 44    | 50    | 63    | 1,826 | 64    | 46    | 15    |

*Table showing Heights of Water in Acushnet Reservoir and Little Quittacas Pond on Dates when Samples of Water were collected for Analysis.*

|                  | Acushnet Reservoir.             | Little Quittacas Pond.          |                   | Acushnet Reservoir.             | Little Quittacas Pond.          |
|------------------|---------------------------------|---------------------------------|-------------------|---------------------------------|---------------------------------|
|                  | Distance below High-water Mark. | Distance below High-water Mark. |                   | Distance below High-water Mark. | Distance below High-water Mark. |
| <b>1893.</b>     | Feet.                           | Feet.                           | <b>1893.</b>      | Feet.                           | Feet.                           |
| Jan. 30, . . . . | 1.4                             | 2.6                             | Aug. 28, . . . .  | 2.6                             | 0.6                             |
| Mar. 1, . . . .  | 0.0                             | 1.75                            | Sept. 28, . . . . | 3.04                            | 1.25                            |
| Apr. 29, . . . . | 0.0                             | 0.8                             | Oct. 23, . . . .  | 2.8                             | 2.2                             |
| May 23, . . . .  | 0.0                             | 1.0                             | Nov. 27, . . . .  | 2.6                             | 2.0                             |
| June 26, . . . . | 0.0                             | 1.2                             | Dec. 17, . . . .  | 2.9                             | 0.7                             |
| July 25, . . . . | 0.9                             | 1.5                             |                   |                                 |                                 |

## NEWBURYPORT.

## WATER SUPPLY OF NEWBURYPORT.—NEWBURYPORT WATER COMPANY.

The use of water from the Merrimack River by the Newburyport Water Company for the supply of the city was the subject of a communication from the State Board of Health\* to the company in November, 1892, pointing out the danger of infection from typhoid fever incurred by the use of this source and advising that a further supply of pure water be obtained without delay. The continued use of the river water was the apparent cause of an epidemic of typhoid fever in Newburyport in January and February, 1893, which led the Board to send a letter relative to this subject to the mayor of the city early in March, a copy of which may be found on page 43 of this volume. The city of Newburyport subsequently applied to the State Board of Health for advice relative to the use of water from the Artichoke River, either directly or after filtration, for the supply of the city, and the reply of the Board may be found on page 44.

The Newburyport Water Company increased its ground-water supply in 1893 by taking the Jackman Spring, so called, and providing a temporary pump and pipe to pump and convey the water from this spring to the present works. It also constructed a well about fifty feet in diameter and fourteen or more feet in depth, a short distance from its present wells, and near the edge of the small reservoir by the pumping station. The works as enlarged, however, are not likely to furnish a sufficient supply for the city of Newburyport.

It will be noticed by reference to the table of analyses on page 242 that a very unusual amount of chlorine was at times present in the water supplied by the company to the city. This result is due to the use of water from the Merrimack River which contained a small amount of sea water.

Analyses of water from the Artichoke River, and from other sources, examined in connection with the investigation of new sources of water supply by the city, will be found in tables which follow.

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\* Report of the State Board of Health for the year 1892, page 37.



## NEWBURYPORT.

*Chemical Examination of Water from the Small Storage Reservoir of the Newburyport Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.          |                    |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|----------------------|--------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.           | Sediment.          | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                      |                    |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 11387   | 1893.<br>Nov. 25    | Distinct,<br>clayey. | Slight,<br>clayey. | 0.10   | 6.00                    | 0.70              | .0000    | .0036       | .0020      | .0016      | .44       | .0180       | .0005     | .1720            | 2.        |

Iron, .0350. Odor, distinctly vegetable. — The sample was collected from the reservoir near the pumping station.

*Microscopical Examination.*

Diatomaceæ, *Cyclotella*, 1; *Meridion*, 1; *Synedra*, 13. Algae, *Conserva*, 2. Fungi, *Orenothrix*, 4. Infusoria, *Peridinium*, 1. Miscellaneous, *Zoöglaea*, 4. Total, 26.

*Chemical Examination of Water from a Faucet in Newburyport, supplied from the Works of the Newburyport Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |                 |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|--------------------|-----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.         | Sediment.       | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 9881    | 1893.<br>Jan. 16    | None.              | None.           | 0.02   | 10.00                   | .0016    | .0096       | 2.88      | .0300       | .0000     | .2175            | 3.0       | .0200 |
| 9905    | Jan. 19             | None.              | V. slight.      | 0.10   | 6.10                    | .0012    | .0030       | .01       | .0300       | .0000     | .1825            | 2.2       | .0125 |
| 9940    | Jan. 23             | -                  | -               | -      | -                       | -        | -           | 21.40     | -           | -         | -                | -         | -     |
| 9970    | Feb. 6              | Slight, clayey.    | V. slight.      | 0.08   | 31.95                   | .0062    | .0102       | 14.54     | .0090       | .0003     | .2445            | 7.3       | .0180 |
| 10086   | Mar. 7              | V. slight.         | V. slight.      | 0.08   | 5.55                    | .0012    | .0012       | .66       | .0150       | .0001     | .1584            | 2.2       | .0170 |
| 10212   | Apr. 5              | Distinct, clayey.  | Slight.         | 0.20   | 5.50                    | .0018    | .0058       | .38       | .0350       | .0001     | .1241            | 1.9       | .0125 |
| 10364   | May 8               | Decided, clayey.   | Slight, earthy. | 0.30   | 6.30                    | .0022    | .0072       | .41       | .0150       | .0000     | .1934            | 1.9       | .0150 |
| 10490   | June 7              | V. slight, clayey. | Slight.         | 0.10   | 5.30                    | .0004    | .0052       | .45       | .0150       | .0000     | .1606            | 2.2       | .0120 |
| 10609   | July 6              | V. slight.         | Slight.         | 0.05   | 6.00                    | .0004    | .0040       | .40       | .0180       | .0000     | .0730            | 2.1       | .0120 |
| 10756   | Aug. 9              | Distinct, clayey.  | V. slight.      | 0.20   | 6.50                    | .0000    | .0040       | .46       | .0070       | .0000     | .1343            | 2.2       | .0200 |
| 11011   | Sept. 11            | Slight.            | Slight.         | 0.10   | 7.30                    | .0000    | .0038       | 1.29      | .0070       | .0000     | .0936            | 2.7       | .0200 |
| 11150   | Oct. 9              | V. slight.         | None.           | 0.05   | 5.50                    | .0000    | .0010       | .46       | .0150       | .0000     | .0192            | 2.2       | .0200 |
| 11306   | Nov. 8              | Distinct.          | None.           | 0.08   | 6.00                    | .0000    | .0024       | .47       | .0180       | .0000     | .0680            | 2.3       | .0180 |
| Av...   | 1893                | .....              | .....           | 0.11   | 8.50                    | .0013    | .0048       | 3.44      | .0178       | .0000     | .1391            | 2.7       | .0164 |
| Av...   | 1887-88*            | .....              | .....           | 0.03   | 5.39                    | .0004    | .0032       | 0.45      | .0312       | .0001     | -                | -         | -     |

\* June, 1887, to May, 1888.

Odor, vegetable, frequently none. — The samples were collected from a faucet at No. 2 State Street.

## NEWBURYPORT.

*Microscopical Examination of Water from a Faucet in Newburyport, supplied from the Works of the Newburyport Water Company.*

[Number of organisms per cubic centimeter.]

|                               | 1893. |      |      |      |       |       |       |       |       |       |       |       |       |
|-------------------------------|-------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                               | Jan.  | Jan. | Jan. | Feb. | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  |
| Day of examination, . . .     | 17    | 21   | -    | 7    | 8     | 7     | 9     | 9     | 7     | 10    | 13    | 10    | 10    |
| Number of sample, . . .       | 9881  | 9905 | 9940 | 9970 | 10086 | 10212 | 10364 | 10490 | 10609 | 10756 | 11011 | 11159 | 11306 |
| PLANTS.                       |       |      |      |      |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .             | 34    | 0    | -    | 4    | 1     | 1     | 490   | 3     | pr.   | 300   | 6     | 5     | 0     |
| Diatoma, . . .                | 1     | 0    | -    | 0    | 0     | 0     | 0     | 0     | 0     | 300   | 0     | 0     | 0     |
| Fragilaria, . . .             | 0     | 0    | -    | 0    | 0     | 0     | 7     | 2     | 0     | 0     | 0     | 5     | 0     |
| Synedra, . . .                | 7     | 0    | -    | 4    | 1     | 1     | 480   | 1     | pr.   | 0     | 2     | 0     | 0     |
| Tabellaria, . . .             | 26    | 0    | -    | 0    | 0     | 0     | 3     | 0     | 0     | 0     | 4     | 0     | 0     |
| Fungi, Crenothrix, . . .      | 0     | 0    | -    | 0    | 1     | 0     | 0     | 0     | 0     | 0     | 36    | 0     | 0     |
| ANIMALS.                      |       |      |      |      |       |       |       |       |       |       |       |       |       |
| Infusoria, . . .              | 2     | 0    | -    | pr.  | 0     | 0     | 78    | 60    | 2     | 1     | 169   | pr.   | 0     |
| Dinobryon, . . .              | 0     | 0    | -    | 0    | 0     | 0     | 8     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, . . .        | 2     | 0    | -    | pr.  | 0     | 0     | 68    | 60    | 2     | 0     | 168   | 0     | 0     |
| Monas, . . .                  | 0     | 0    | -    | 0    | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     |
| Peridinium, . . .             | 0     | 0    | -    | pr.  | 0     | 0     | 0     | 0     | 0     | 1     | 1     | pr.   | 0     |
| Miscellaneous, Zoöglæa, . . . | 84    | 0    | -    | 8    | 232   | 0     | 6     | 16    | 0     | 0     | 92    | 10    | 76    |
| TOTAL, . . .                  | 120   | 0    | -    | 12   | 234   | 1     | 574   | 79    | 2     | 301   | 303   | 16    | 76    |

*Chemical Examination of Water from Tubular Test Wells at Newburyport.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |                |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------------|----------------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.        | Sediment.      | Color. |                         | Free.    | Albu- minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | 1893.               |                   |                |        |                         |          |               |           |             |           |                  |           |       |
| 11388   | Nov. 25             | Slight, clayey.   | Cons., sand.   | 0.0    | 19.80                   | .0006    | .0006         | 2.58      | .0300       | .0003     | .1032            | 11.8      | .0020 |
| 11390   | Nov. 25             | None.             | None.          | 0.0    | 19.80                   | .0010    | .0002         | 2.12      | .0000       | .0000     | .0731            | 10.7      | .0100 |
| 11423   | Nov. 29             | Distinct, clayey. | Cons., clayey. | 0.0    | 24.70                   | .0012    | .0004         | 1.50      | .0000       | .0000     | .1435            | 9.0       | .1140 |
| Av.     |                     |                   |                | 0.0    | 21.43                   | .0009    | .0004         | 2.10      | .0100       | .0001     | .3259            | 1.05      | .0420 |

Odor, none. — The first sample was collected from a tubular test well just below Frost's ice pond in the valley of a tributary of Little River, about one mile south-west of the centre of the city of Newburyport; the second sample from a tubular test well located on the northerly side of Little River just below the point where it is crossed by the Byfield road, about on the line between Newburyport and Newbury; the last sample, from a tubular test well in the valley of Little River, about half a mile or more north-west of the well last described.

*Microscopical Examination.*

No. 11388. No organisms.

No. 11390. Miscellaneous, Zoöglæa, 1.

No. 11423. Diatomaceæ, Synedra, 1. Miscellaneous, Zoöglæa, 1. Total, 2.

## NEWBURYPORT.

*Chemical Examination of Water from the Artichoke River in West Newbury.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1893.   |                     |             |            |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 10265   | Apr. 18             | V. slight.  | V. slight. | 0.55   | 5.50                    | 2.25              | .0000    | .0254       | .0214      | .0040      | .59       | .0030       | .0000     | .6205            | 2.1       |
| 11467   | Dec. 7              | None.       | None.      | 0.55   | 6.60                    | 1.00              | .0000    | .0182       | .0182      | .0020      | .68       | .0050       | .0002     | .5109            | 2.6       |
| 11389   | Nov. 25             | V. slight.  | V. slight. | 0.70   | 7.70                    | 2.55              | .0008    | .0240       | .0222      | .0018      | .82       | .0000       | .0165     | .9116            | 3.5       |
| 11468   | Dec. 7              | None.       | V. slight. | 0.50   | 6.60                    | 1.20              | .0000    | .0182       | .0144      | .0018      | .67       | .0030       | .0001     | .4719            | 2.6       |
| Av.     | .....               | .....       | .....      | 0.58   | 6.60                    | 1.75              | .0002    | .0210       | .0186      | .0024      | .69       | .0028       | .0042     | .6287            | 2.7       |

Iron, of the first sample, .0055; of the second, .0120; of the last two, .0110. Odor of the first two samples, faintly vegetable; of the last two, distinctly vegetable. — The first two samples were collected from the Artichoke River, about two miles above its mouth, at the Quaker Church Road crossing; the last two samples from the west branch of the Artichoke River at the first road crossing above its junction with the main stream.

*Microscopical Examination.*

The total number of organisms found in each of these samples was as follows: — No. 10265, 42; No. 11467, 3; No. 11389, 12; No. 11468, 8.

## WATER SUPPLY OF NEWTON.

*Chemical Examination of Water from a Faucet at the Newton Water Works Pumping Station.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |               |           | Chlorine. | NITROGEN AS |       | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|---------------|-----------|-----------|-------------|-------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albu- minoid. | Nitrates. |           | Nitrites.   |       |                  |           |       |
|         |                     |             |            |        |                         |          |               |           |           |             |       |                  |           |       |
| 1893.   |                     |             |            |        |                         |          |               |           |           |             |       |                  |           |       |
| 9912    | Jan. 23             | None.       | None.      | 0.00   | 5.05                    | .0000    | .0012         | .41       | .0250     | .0000       | .0401 | 2.2              | .0050     |       |
| 10149   | Mar. 22             | Slight.     | Cons.      | 0.10   | 4.65                    | .0010    | .0034         | .40       | .0120     | .0000       | .1548 | 2.2              | .0260     |       |
| 10406   | May 17              | Slight.     | V. slight. | 0.03   | 5.45                    | .0000    | .0020         | .40       | .0350     | .0000       | .0474 | 2.2              | .0110     |       |
| 10630   | July 10             | V. slight.  | V. slight. | 0.00   | 5.20                    | .0008    | .0022         | .31       | .0250     | .0000       | .0511 | 2.1              | .0050     |       |
| 11354   | Nov. 21             | None.       | Slight.    | 0.02   | 5.05                    | .0000    | .0008         | .38       | .0000     | .0000       | .1344 | 2.6              | .0125     |       |
| Av...   | .....               | .....       | .....      | 0.03   | 5.08                    | .0004    | .0019         | .38       | .0194     | .0000       | .0856 | 2.3              | .0119     |       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |       |       |     |       |       |   |   |     |       |
|---|-------|---|---|------|------|-------|-------|-----|-------|-------|---|---|-----|-------|
| - | 1887* | - | - | 0.00 | 4.97 | .0005 | .0070 | .38 | .0047 | -     | - | - | -   | -     |
| - | 1888  | - | - | 0.01 | 4.64 | .0009 | .0111 | .35 | .0072 | .0001 | - | - | -   | -     |
| - | 1889  | - | - | 0.00 | 3.93 | .0002 | .0061 | .30 | .0128 | .0001 | - | - | -   | -     |
| - | 1890† | - | - | 0.00 | -    | .0000 | .0014 | .32 | .0250 | .0001 | - | - | -   | -     |
| - | 1891† | - | - | 0.00 | 4.25 | .0002 | .0072 | .31 | .0250 | .0000 | - | - | 1.6 | -     |
| - | 1892  | - | - | 0.02 | 5.13 | .0006 | .0028 | .35 | .0190 | .0001 | - | - | 2.4 | -     |
| - | 1893  | - | - | 0.03 | 5.08 | .0004 | .0019 | .38 | .0194 | .0000 | - | - | 2.3 | .0119 |

\* June to December.

† February.

NOTE to analyses of 1893; Odor of 10149, very faintly vegetable; of the remaining samples, none. — The samples were collected from a faucet at the pumping station, and represent the water as it comes from the covered filter-gallery.

Analyses for the years 1887 to 1890, inclusive, represent water drawn from an open filter-basin. In 1890 the works for collecting ground water were enlarged by the construction of a long wooden filter-gallery, reinforced by tubular wells. A portion of this gallery, seven hundred and thirty-two feet in length, replaced an equal portion of the old open filter basin. In 1892 the remaining portion of the open filter-basin was replaced by an extension of the filter-gallery, and after December of that year the water pumped for the supply of the city was not exposed to light at any point.

NEWTON.

*Microscopical Examination of Water from a Faucet at the Newton Water Works Pumping Station.*

[Number of organisms per cubic centimeter.]

|                                 | 1893.    |        |       |       |           |
|---------------------------------|----------|--------|-------|-------|-----------|
|                                 | January. | March. | May.  | July. | November. |
| Day of examination, . . . . .   | 24       | 23     | 18    | 13    | 22        |
| Number of sample, . . . . .     | 9912     | 10149  | 10406 | 10680 | 11354     |
| <b>PLANTS.</b>                  |          |        |       |       |           |
| Diatomaceæ, . . . . .           | 0        | 0      | 7     | 16    | 0         |
| Cyclotella, . . . . .           | 0        | 0      | pr.   | 12    | 0         |
| Fragilaria, . . . . .           | 0        | 0      | 0     | 3     | 0         |
| Melosira, . . . . .             | 0        | 0      | 6     | 0     | 0         |
| Synedra, . . . . .              | 0        | 0      | 1     | 3     | 0         |
| Algae, . . . . .                | 0        | pr.    | 5     | 6     | 0         |
| Closterium, . . . . .           | 0        | 0      | 0     | 3     | 0         |
| Protococcus, . . . . .          | 0        | 0      | 0     | 3     | 0         |
| Zoospores, . . . . .            | 0        | pr.    | 5     | 0     | 0         |
| Fungi, Crenothrix, . . . . .    | 0        | 0      | 1     | 26    | 0         |
| <b>ANIMALS.</b>                 |          |        |       |       |           |
| Infusoria, Trachelomonas, . . . | 0        | pr.    | pr.   | 0     | 0         |
| Miscellaneous, Zoöglæa, . . . . | 32       | 7      | 88    | 18    | 5         |
| TOTAL, . . . . .                | 32       | 7      | 99    | 68    | 5         |

*Chemical Examination of Water from the Covered Distributing Reservoir of the Newton Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | Residue on Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-------------------|--------|-------------------------|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.         | Color. |                         | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | 1893.               |             |                   |        |                         |          |                  |           |             |           |                  |           |       |
| 9911    | Jan. 23             | None.       | V. slight.        | 0.00   | 5.55                    | .0000    | .0016            | .40       | .0200       | .0000     | .0438            | 2.5       | .0000 |
| 10148   | Mar. 22             | Slight.     | Cons.,<br>earthy. | 0.10   | 6.35                    | .0000    | .0040            | .42       | .0150       | .0001     | .0504            | 2.9       | .0525 |
| 10405   | May 17              | None.       | Slight.           | 0.02   | 6.95                    | .0000    | .0030            | .39       | .0400       | .0000     | .0511            | 3.0       | .0060 |
| 10629   | July 10             | V. slight.  | Slight,<br>rusty. | 0.02   | 7.00                    | .0000    | .0024            | .32       | .0200       | .0000     | .0511            | 3.5       | .0175 |
| 11355   | Nov. 21             | V. slight.  | V. slight.        | 0.05   | 6.15                    | .0000    | .0026            | .38       | .0150       | .0000     | .1428            | 3.0       | .0220 |
| Av...   | .....               | .....       | .....             | 0.04   | 6.40                    | .0000    | .0027            | .38       | .0220       | .0000     | .0678            | 3.0       | .0196 |

Odor of No. 10148, very faintly vegetable; of No. 10405, faintly unpleasant; of the remaining samples, none. The odor of No. 11355 became distinctly unpleasant after standing in the laboratory one day. — The samples were collected from the reservoir.

## NEWTON.

*Microscopical Examination of Water from the Covered Distributing Reservoir of the Newton Water Works.*

[Number of organisms per cubic centimeter.]

|                                   | 1893.    |            |           |           |           |
|-----------------------------------|----------|------------|-----------|-----------|-----------|
|                                   | January. | March.     | May.      | July.     | November. |
| Day of examination, . . . . .     | 24       | 23         | 18        | 13        | 22        |
| Number of sample, . . . . .       | 9911     | 10148      | 10405     | 10629     | 11355     |
| <b>PLANTS.</b>                    |          |            |           |           |           |
| Diatomaceæ, Melosira, . . . . .   | 0        | 3          | 0         | 0         | 0         |
| Miscellaneous, Zoögkeæ, . . . . . | 0        | 132        | 11        | 30        | 22        |
| <b>TOTAL,</b> . . . . .           | <b>0</b> | <b>135</b> | <b>11</b> | <b>30</b> | <b>22</b> |

*Chemical Examination of Water from the Main Underdrain of the Hyde Brook Division of the Newton Sewerage System.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.    |                            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|----------------|----------------------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.     | Sediment.                  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1893.</b>        |                |                            |        |                         |          |             |           |             |           |                  |           |       |
| 9573    | Jan. 10             | None.          | V. slight.                 | 0.00   | 22.70                   | .0074    | .0024       | 2.50      | 1.0000      | .0008     | -                | 11.2      | .0020 |
| 10603   | July 5              | None.          | V. slight.                 | 0.00   | 26.10                   | .0020    | .0028       | 2.56      | .3000       | .0010     | .0438            | 9.9       | .0000 |
| 10714   | July 31             | None.          | Slight, sandy.             | 0.00   | 26.70                   | .0100    | .0030       | 2.80      | 1.2000      | .0012     | .0000            | 8.0       | .0100 |
| 10737   | Aug. 7              | Distinct.      | Cons., earthy & floccul't. | 0.02   | 32.70                   | .0130    | .0026       | 2.67      | 1.2000      | .0015     | .0333            | 9.6       | .0350 |
| 10894   | Aug. 28             | None.          | Slight, fibrous.           | 0.00   | 26.40                   | .0056    | .0020       | 2.70      | 1.2500      | .0018     | .0316            | 9.6       | .0100 |
| 11246   | Oct. 24             | Slight, milky. | Cons., fibrous.            | 0.15   | 27.30                   | .0300    | .0060       | 2.35      | 1.0500      | .0050     | .1786            | 8.7       | .0150 |
| 11563   | Dec. 30             | None.          | Slight.                    | 0.00   | 21.20                   | .0112    | .0050       | 2.20      | .7500       | .0006     | .0231            | 8.7       | .0050 |
| Av.*    | .....               | .....          | .....                      | 0.03   | 25.43                   | .0140    | .0037       | 2.48      | .9550       | .0018     | .0640            | 9.4       | .0099 |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

Odor of No. 10714, faintly earthy, disappearing on heating; of No. 10737, distinct, becoming disagreeable on heating; of No. 11246, decidedly musty, disappearing on heating; of No. 11563, none, becoming faintly musty on standing one day in the laboratory; of the remaining samples, none.—The samples were collected from the underdrain at its outlet.

NEWTON.

*Microscopical Examination of Water from the Main Underdrain of the Hyde Brook Division of the Newton Sewerage System.*

[Number of organisms per cubic centimeter.]

|                                   | 1893. |       |       |       |       |       | 1894. |
|-----------------------------------|-------|-------|-------|-------|-------|-------|-------|
|                                   | Jan.  | July. | July. | Aug.  | Aug.  | Oct.  | Jan.  |
| Day of examination, . . . . .     | 14    | 7     | 31    | 8     | 29    | 25    | 1     |
| Number of sample, . . . . .       | 9873  | 10603 | 10714 | 10737 | 10894 | 11246 | 11563 |
| PLANTS.                           |       |       |       |       |       |       |       |
| Diatomaceæ, . . . . .             | 0     | pr.   | 0     | 25    | 0     | 0     | 0     |
| Melosira, . . . . .               | 0     | 0     | 0     | 5     | 0     | 0     | 0     |
| Synedra, . . . . .                | 0     | pr.   | 0     | 20    | 0     | 0     | 0     |
| Algæ, Pediastrum, . . . . .       | 0     | 0     | 0     | 15    | 0     | 0     | 0     |
| Fungi, . . . . .                  | 0     | 12    | 6     | 13    | 0     | 8     | 28    |
| Crenothrix, . . . . .             | 0     | 0     | 0     | 7     | 0     | 3     | 28    |
| Molds, . . . . .                  | 0     | 12    | 6     | 6     | 0     | 5     | 0     |
| ANIMALS.                          |       |       |       |       |       |       |       |
| Infusoria, Monas, . . . . .       | pr.   | 14    | 0     | 0     | 0     | 0     | 0     |
| Miscellaneous, Zoöglæa, . . . . . | 0     | pr.   | 6     | 14    | 2     | 88    | 4     |
| TOTAL, . . . . .                  | pr.   | 26    | 12    | 67    | 2     | 96    | 32    |

*Chemical Examination of Water from Main Underdrain of the Cheesecake Brook Division of the Newton Sewerage System.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                  |        | Residue on Evaporation. | AMMONIA. |           | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------------|--------|-------------------------|----------|-----------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.        | Color. |                         | Free.    | Albimoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | 1893.               |             |                  |        |                         |          |           |           |             |           |                  |           |       |
| 10713   | July 31             | Distinct.   | Cons.            | 0.03   | 13.10                   | .0076    | .0018     | 1.40      | .4000       | .0004     | .0000            | 4.8       | .0200 |
| 10736   | Aug. 7              | Decided.    | Cons.,<br>rusty. | 0.05   | 14.20                   | .0038    | .0008     | 1.56      | .3000       | .0004     | .0000            | 5.6       | .0700 |
| 10895   | Aug. 28             | Distinct.   | Heavy.           | 0.10   | 14.40                   | .0072    | .0014     | 1.50      | .2500       | .0002     | .0592            | 5.6       | .0800 |
| 11245   | Oct. 24             | Distinct.   | Cons.,<br>milky. | 0.18   | 20.40                   | .0050    | .0012     | 1.53      | .2900       | .0010     | .0494            | 6.0       | .0650 |
| 11564   | Dec. 30             | Distinct.   | Heavy.           | 0.01   | 15.50                   | .0120    | .0022     | 1.59      | .3250       | .0008     | .0077            | 7.4       | .0480 |
| Av.*    |                     |             |                  | 0.08   | 15.83                   | .0075    | .0016     | 1.51      | .3225       | .0006     | .0217            | 6.0       | .0520 |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

Odor of the first sample, faintly mouldy; of the second, none, becoming faintly earthy on heating; of the last sample, none, becoming faintly vegetable on heating; of the remaining samples, none. — The samples were collected from the underdrain at its outlet.

## NEWTON.

*Microscopical Examination of Water from the Main Underdrain of the Cheese-cake Brook Division of the Newton Sewerage System.*

[Number of organisms per cubic centimeter.]

|                                   | 1893. |         |         |          |          |
|-----------------------------------|-------|---------|---------|----------|----------|
|                                   | July. | August. | August. | October. | January. |
| Day of examination, . . . . .     | 31    | 8       | 29      | 25       | 1        |
| Number of sample, . . . . .       | 10713 | 10736   | 10895   | 11245    | 11564    |
| PLANTS.                           |       |         |         |          |          |
| Fungi, Crenothrix, . . . . .      | 1,000 | 3,840   | 840     | 1,920    | 2,880    |
| ANIMALS.                          |       |         |         |          |          |
| Infusoria, Monas, . . . . .       | 0     | 1       | 0       | 0        | 0        |
| Miscellaneous, Zoöglæa, . . . . . | 180   | 80      | 32      | 15       | 2        |
| TOTAL, . . . . .                  | 1,180 | 3,921   | 872     | 1,935    | 2,882    |

*Chemical Examination of Water from the Main Underdrain beneath the Laundry Brook Valley Sewer, Newton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.    |                 |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|----------------|-----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.     | Sediment.       | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | 1893.               |                |                 |        |                         |          |             |           |             |           |                  |           |       |
| 11247   | Oct. 24             | Slight, milky. | Cons., fibrous. | 0.15   | 17.90                   | .0092    | .0024       | 1.37      | .4000       | .0010     | .0988            | 6.6       | .0650 |
| 11562   | Dec. 30             | Distinct.      | Cons.           | 0.01   | 15.90                   | .0072    | .0025       | 1.66      | .3000       | .0003     | .0577            | 7.6       | .0400 |

Odor of the first sample, faintly vegetable; of the last, none. — The samples were collected from the underdrain at its outlet.

*Microscopical Examination.*

No. 11247. Fungi, *Crenothrix*, 920. Miscellaneous, *Zoöglæa*, 40. Total, 960.

No. 11562. Fungi, *Crenothrix*, 2,240.

## NORTHAMPTON.

## WATER SUPPLY OF NORTHAMPTON.

*Chemical Examination of Water from the Upper and Lower Storage Reservoirs of the Northampton Water Works on Roberts' Meadow Brook.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. |           |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. | Oxygen Consumed. | Hardness. |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1893.   |                     |             |            |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 10836   | Aug. 16             | None.       | V. slight. | 0.05   | 5.40                    | 1.50              | .0000    | .0058       | .0028      | .0010      | .11       | .0070       | .0000     | .1404            | 1.9       |
| 10837   | Aug. 16             | Distinct.   | Slight.    | 0.12   | 5.55                    | 1.70              | .0000    | .0140       | .0076      | .0064      | .12       | .0000       | .0000     | .2028            | 1.9       |

Iron in the first sample, .0040; in the last, .0165. Odor of the first sample, none, becoming distinctly vegetable on heating; of the last sample, none.—The first sample was collected from the upper reservoir at Roberts' Meadow; the last from the lower reservoir at Leeds.

*Microscopical Examination.*

No. 10836. Diatomaceæ, *Fragilaria*, 5; *Gomphonema*, 4; *Synedra*, 1. Miscellaneous, *Zoëglæa*, 28. Total, 38.

No. 10837. Diatomaceæ, *Cyclotella*, 2; *Diatoma*, 2; *Epithemia*, 2; *Fragilaria*, 14; *Gomphonema*, 2; *Melosira*, 4; *Navicula*, 1; *Pinnularia*, 8; *Synedra*, 7,360; *Tabellaria*, 1. Infusoria, *Peridinium*, 2. Vermes, *Polyarthra*, 2. Miscellaneous, *Zoëglæa*, 36. Total, 7,431.

## NORTH ANDOVER.

The advice of the State Board of Health to the town of North Andover with reference to taking a supply of water for the town from Great Pond may be found on page 44 of this volume. The following analysis of a sample of water from Boston Brook in North Andover was made during an investigation for a new source of water supply for Melrose.

*Chemical Examination of Water from Boston Brook, North Andover.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 9941    | 1893.<br>Jan. 25    | V. slight.  | Slight.   | 1.70   | 7.20                    | 3.40              | .0042    | .0254       | .0208      | .0046      | .39       | .0070       | .0001     | 1.6133           | 2.6       |

Iron, .0100. Odor, faintly vegetable. — The sample was collected from the brook just below the point where it is crossed by the Salem and Lawrence turnpike, near Boston Hill.

*Microscopical Examination.*

Diatomaceæ, *Diatoma*, 9; *Meridion*, 8; *Navicula*, 1. Fungi, *Crenothrix*, 1. Total, 19.



## NORTH ATTLEBOROUGH.

## WATER SUPPLY OF NORTH ATTLEBOROUGH.

*Chemical Examination of Water from the Well of the North Attleborough Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.          |           |        | Residue on Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|----------------------|-----------|--------|-------------------------|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.           | Sediment. | Color. |                         | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 10188   | 1892.<br>Mar. 29    | V. slight.           | None.     | 0.0    | 5.65                    | .0000    | .0000            | .57       | .0400       | .0001     | .0219            | 2.6       | .0000 |
| 10646   | July 11             | V. slight,<br>milky. | None.     | 0.0    | 6.10                    | .0006    | .0010            | .62       | .0500       | .0000     | .0000            | 3.0       | .0080 |

*Averages of Analyses of Previous Years.*

|   |       |   |   |     |      |       |       |     |       |       |       |     |       |
|---|-------|---|---|-----|------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1887* | - | - | 0.0 | 6.28 | .0001 | .0011 | .50 | .0290 | -     | -     | -   | -     |
| - | 1888  | - | - | 0.0 | 6.27 | .0002 | .0018 | .50 | .0288 | .0000 | -     | -   | -     |
| - | 1889† | - | - | 0.0 | 6.09 | .0000 | .0012 | .55 | .0414 | .0000 | -     | -   | -     |
| - | 1892‡ | - | - | 0.0 | 5.95 | .0008 | .0018 | .53 | .0416 | .0000 | -     | 3.0 | -     |
| - | 1893  | - | - | 0.0 | 5.88 | .0003 | .0005 | .60 | .0450 | .0000 | .0100 | 2.8 | .0040 |

\* June to December.

† January to May.

‡ April to December.

NOTE to analyses of 1893: Odor, none. — The samples were collected from a faucet at the pumping station.

*Microscopical Examination.*

No. 10188. Miscellaneous, Zoöglæa, 9.

No. 10646. Miscellaneous, Zoöglæa, 1.

*Chemical Examination of Water from Faucets in North Attleborough, supplied from the North Attleborough Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                      |        | Residue on Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|---------------------|----------------------|--------|-------------------------|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.          | Sediment.            | Color. |                         | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 10189   | 1893.<br>Mar. 29    | Decided,<br>yellow. | Cons.,<br>iron rust. | 0.03   | 6.90                    | .0000    | .0006            | .56       | .0400       | .0001     | .0620            | 2.9       | .2400 |
| 10647   | July 11             | None.               | None.                | 0.00   | 6.00                    | .0006    | .0016            | .62       | .0700       | .0000     | .0438            | 2.6       | .0070 |

Odor, none. — The first sample was collected from a dead end which had not been flushed for a month or more. The second sample was collected from a faucet near the center of the town.

*Microscopical Examination.*

No. 10189. Miscellaneous, Zoöglæa, 824.

No. 10647. Diatomaceæ, Stauroneta, 1. Algæ, Pediatrum, 1. Total, 2.

## NORTHBOROUGH.

## WATER SUPPLY OF NORTHBOROUGH.

*Chemical Examination of Water from the Northborough Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                     |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 10395   | 1893.<br>May 13     | Slight.             | Slight.           | 1.50   | 3.15                            | 1.65                 | .0002    | .0204       | .0186      | .0018           | .15       | .0150          | .0001     | .9453            | 0.8       |
| 11036   | Sept. 17            | Distinct,<br>green. | Slight.           | 0.50   | 4.70                            | 2.05                 | .0000    | .0248       | .0200      | .0048           | .38       | .0000          | .0000     | .6162            | 1.2       |
| 11037   | Sept. 17            | Decided,<br>green.  | Cons.,<br>yellow. | 0.40   | 4.50                            | 1.95                 | .0000    | .0276       | .0156      | .0120           | .28       | .0050          | .0000     | .4914            | 0.9       |
| 10396   | May 15              | Slight.             | V. slight.        | 0.90   | 3.60                            | 1.65                 | .0000    | .0152       | .0124      | .0028           | .12       | .0070          | .0001     | .5913            | 0.8       |

Iron in the upper reservoir, .0075; in the lower reservoir, .0130. Odor, vegetable. — The first two samples were collected from the upper reservoir; the third, from the lower reservoir, and the last from a faucet in the town.

*Microscopical Examination of Water from the Northborough Water Works.*

[Number of organisms per cubic centimeter.]

|                                | 1893. |            |            |       |
|--------------------------------|-------|------------|------------|-------|
|                                | May.  | September. | September. | May.  |
| Day of examination, . . . . .  | 17    | 19         | 19         | 17    |
| Number of sample, . . . . .    | 10395 | 11036      | 11037      | 10396 |
| PLANTS.                        |       |            |            |       |
| Diatomaceæ, . . . . .          | 63    | 6          | 2,095      | 63    |
| Asterionella, . . . . .        | 1     | 0          | 0          | 2     |
| Cyclotella, . . . . .          | 0     | 0          | 28         | 0     |
| Diatoma, . . . . .             | 0     | 0          | 200        | 0     |
| Epithemia, . . . . .           | 0     | 0          | 1          | 0     |
| Fragilaria, . . . . .          | 2     | 0          | 0          | 0     |
| Gomphonema, . . . . .          | pr.   | 0          | 1          | 0     |
| Melosira, . . . . .            | 1     | 0          | 260        | 26    |
| Navicula, . . . . .            | pr.   | 1          | 1          | 0     |
| Pinnularia, . . . . .          | 1     | 0          | 1          | 0     |
| Surirella, . . . . .           | 0     | 0          | 2          | 0     |
| Synedra, . . . . .             | 60    | 3          | 1          | 34    |
| Tabellaria, . . . . .          | 4     | 2          | 1,600      | 1     |
| Cyanophyceæ, Nostoc, . . . . . | 1     | 1          | 0          | 0     |
| Algeæ, . . . . .               | 4     | 0          | 21         | 3     |
| Chlorococcus, . . . . .        | 0     | 0          | 18         | 0     |
| Cosmarium, . . . . .           | 0     | 0          | 0          | 1     |
| Scenedesmus, . . . . .         | 0     | 0          | 0          | 2     |
| Stauroastrum, . . . . .        | 4     | 0          | 0          | 0     |
| Zoospores, . . . . .           | pr.   | 0          | 3          | 0     |
| Fungi, Crenothrix, . . . . .   | 44    | 2          | 0          | 0     |

## NORTHBOROUGH.

*Microscopical Examination of Water from the Northborough Water Works*  
— Concluded.

[Number of organisms per cubic centimeter.]

|                                              | 1893. |            |            |      |
|----------------------------------------------|-------|------------|------------|------|
|                                              | May.  | September. | September. | May. |
| <b>ANIMALS.</b>                              |       |            |            |      |
| <b>Rhizopoda, <i>Diffugia</i>,</b> . . . . . | 0     | 0          | 1          | 0    |
| <b>Infusoria,</b> . . . . .                  | 2     | 10         | 37         | 1    |
| <i>Peridinium</i> , . . . . .                | 2     | 9          | 36         | 1    |
| <i>Trachelomonas</i> , . . . . .             | 0     | 1          | 1          | 0    |
| <b>Vermes,</b> . . . . .                     | 0     | 8          | 18         | 0    |
| <i>Anura</i> , . . . . .                     | 0     | 5          | 12         | 0    |
| <i>Polyarthra</i> , . . . . .                | 0     | 1          | 3          | 0    |
| Rotatorian ova, . . . . .                    | 0     | 2          | 3          | 0    |
| <b>Crustacea,</b> . . . . .                  | 0     | 0          | 0          | .02  |
| <i>Daphnia</i> , . . . . .                   | 0     | 0          | 0          | .01  |
| Entomostracan ova, . . . . .                 | 0     | 0          | 0          | .01  |
| <b>Miscellaneous, Zoöglæa,</b> . . . . .     | 28    | 2          | 0          | 0    |
| <b>TOTAL,</b> . . . . .                      | 146   | 29         | 2,172      | 67   |

## WATER SUPPLY OF NORTH BROOKFIELD.

*Description of Works.*—The works are owned by the town and were completed in 1893. The sources of supply are Doane Pond and North Pond, formerly known as Horse Pond, supplemented by water diverted into it from North Brook. Water is pumped by water power at a station near Doane Pond to a distributing reservoir on Bell Hill and thence distributed to the town.

Water can be drawn from either pond, but it is proposed to draw the supply for domestic use from Doane Pond, using the surplus water from Doane Pond, in connection with the water from North Pond, to furnish power for pumping.

## NORTH BROOKFIELD.

The areas of watersheds (including the water surfaces) of sources controlled by the town, as determined by actual survey, are as follows :

|                                             |                  |
|---------------------------------------------|------------------|
| North Brook, . . . . .                      | 487.9 acres.     |
| Side Hill Canal from North Brook, . . . . . | 25.0 "           |
| North Pond, . . . . .                       | 195.6 "          |
| Doane Pond, . . . . .                       | 899.7 "          |
| Total, . . . . .                            | <u>1,608.2</u> " |

The size of the Doane Pond watershed, as given in the table, includes the whole of Stoddard Brook, which has a watershed of 425.8 acres. Provision has been made by which the water of nearly all of this brook can be turned into North Pond when it is desirable to do so.

With the exception of a portion of the watershed of North Brook, which rises in New Braintree, the watersheds of the sources of supply are within the limits of North Brookfield.

North Pond has an area of 69.6 acres and a capacity of about 350,000,000 gallons. It has been used for many years as a storage reservoir to supply power to a mill situated just below Doane Pond. A new dam six feet higher than the old one has been constructed by the town about 500 feet down stream from the old dam, thus greatly increasing the area and storage capacity of the pond. It is said that the pond is thirty feet deep in some places and may average eighteen feet. The water of North Pond is conveyed to the pumping station, situated just below Doane Pond, by means of a canal, without passing through Doane Pond.

Doane Pond is an artificial reservoir constructed many years ago for use as a mill pond. Since its acquisition by the town as a source of water supply the dam has been raised three feet, increasing its area to 30.9 acres and its capacity to 53,800,000 gallons.

A filter entirely surrounded by water has been constructed at Doane Pond near the dam, by building two concentric walls having an annular space five feet wide, filled with gravel, between them. In the centre is a filtered-water well fifteen feet in diameter and fifteen feet deep. Water for the supply of the town is drawn from this well.

The distributing reservoir is rectangular in shape, 159 by 117 feet at the foot of the slopes and 222 by 180 feet at the top of the slopes

**NORTH BROOKFIELD.**

inside. It is nineteen feet in depth from the top of the embankments and when filled to a depth of fifteen feet will contain about 2,950,000 gallons of water. The slopes are lined with clay puddle four feet in thickness, covered with a six-inch layer of broken stone, upon which is laid a stone paving one foot in thickness. The bottom is covered with broken stone and binding material to a depth of six inches.

Water enters the reservoir at the bottom on the north side and is drawn out about one foot from the bottom on the south side. An arrangement has been made whereby water may be sprayed into the reservoir from a pipe near its centre. It is intended to pump all water to the distributing reservoir, but a direct connection has been made whereby water may be pumped directly to the town in case of emergency. The distributing mains are of cast-iron.

*Chemical Examination of Water from Faucets in North Brookfield, supplied from the North Brookfield Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.       | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrates. |                  |           |
|         |                     |             |                 |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1893.   |                     |             |                 |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 10394   | May 15              | Slight.     | Cons., green.   | 0.30   | 3.45                    | 1.00              | .0048    | .0210       | .0176      | .0034      | .13       | .0090       | .0001     | .3942            | 1.4       |
| 11038   | Sept. 18            | Distinct.   | Slight, yellow. | 0.90   | 4.40                    | 2.00              | .0006    | .0200       | .0230      | .0030      | .15       | .0070       | .0001     | .6396            | 1.5       |

Iron, .0433. Odor of the first sample, distinctly vegetable and unpleasant; of the last sample, none.

*Microscopical Examination.*

No. 10394. Diatomaceæ, *Asterionella*, 8,240; *Tabellaria*, 7. Algae, *Zoöspores*, 18. Infusoria, *Dinobryon cases*, 9; *Euglena*, 1; *Peridinium*, 78. Miscellaneous, *Zoöglæa*, 3. Total, 8,356.

No. 11038. Diatomaceæ, *Asterionella*, 3,840. Algae, *Conferæ*, 1; *Cosmarium*, 1; *Glaucocystis*, 1; *Protococcus*, 80; *Staurastrum*, 1; *Xanthidium*, 1; *Zoöspores*, 1. Infusoria, *Dinobryon cases*, 1. Total, 3,927.

**WATER SUPPLY OF NORWOOD.**

The organism *Uroglæna*, which was present in large numbers in the water of Buckmaster Pond in 1892, reappeared in much smaller numbers for a short time in the early part of 1893, and also in very small numbers toward the end of the year. A description of this organism and an account of its effect upon the taste and odor of water may be found in the annual report of the State Board of Health for 1891, pages 645-658.

## NORWOOD.

*Chemical Examination of Water from Buckmaster Pond, Dedham.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 9884    | 1893.<br>Jan. 16    | Slight.     | Slight.    | 0.05   | 2.90                    | 1.15              | .0084    | .0182       | .0156      | .0026      | .40       | .0030       | .0000     | .2372            | 0.8       |
| 9891    | Jan. 18             | Distinct.   | Slight.    | 0.05   | -                       | -                 | -        | -           | -          | -          | -         | -           | -         | -                | -         |
| 9933    | Jan. 25             | V. slight.  | V. slight. | 0.05   | -                       | -                 | -        | -           | -          | -          | -         | -           | -         | -                | -         |
| 9985    | Feb. 8              | V. slight.  | V. slight. | 0.05   | 2.75                    | 0.90              | .0140    | .0244       | .0206      | .0038      | .44       | .0050       | .0000     | .2263            | 0.8       |
| 10078   | Mar. 6              | Slight.     | Slight.    | 0.08   | 2.80                    | 0.80              | .0156    | .0156       | .0118      | .0038      | .32       | .0070       | .0001     | .1605            | 0.9       |
| 10211   | Apr. 4              | V. slight.  | V. slight. | 0.10   | 2.90                    | 0.80              | .0134    | .0148       | .0136      | .0012      | .30       | .0070       | .0000     | .2299            | 0.8       |
| 10384   | May 10              | Slight.     | Slight.    | 0.12   | 2.55                    | 1.00              | .0026    | .0184       | .0104      | .0080      | .32       | .0030       | .0000     | .2555            | 0.6       |
| 10479   | June 5              | Slight.     | Slight.    | 0.15   | 2.40                    | 0.80              | .0004    | .0258       | .0186      | .0072      | .31       | .0050       | .0000     | .3525            | 0.8       |
| 10507   | July 5              | V. slight.  | Slight.    | 0.08   | 2.45                    | 1.40              | .0014    | .0240       | .0194      | .0046      | .30       | .0000       | .0000     | .3139            | 0.5       |
| 10750   | Aug. 8              | Slight.     | Slight.    | 0.05   | 2.55                    | 1.50              | .0000    | .0158       | .0136      | .0022      | .36       | .0000       | .0000     | .2146            | 0.5       |
| 10970   | Sept. 5             | Slight.     | Slight.    | 0.08   | 2.45                    | 1.20              | .0000    | .0202       | .0142      | .0060      | .34       | .0000       | .0000     | .3240            | 0.8       |
| 11134   | Oct. 2              | Slight.     | Slight.    | 0.05   | 2.75                    | 1.50              | .0014    | .0150       | .0128      | .0022      | .38       | .0000       | .0000     | .2233            | 0.5       |
| 11291   | Nov. 6              | V. slight.  | V. slight. | 0.05   | 2.35                    | 0.80              | .0000    | .0284       | .0210      | .0074      | .20       | .0030       | .0000     | .3237            | 0.5       |
| 11448   | Dec. 5              | V. slight.  | Slight.    | 0.03   | 2.60                    | 1.05              | .0050    | .0178       | .0150      | .0028      | .34       | .0000       | .0003     | .1911            | 0.5       |
| Av.     | .....               | .....       | .....      | 0.07   | 2.62                    | 1.08              | .0052    | .0199       | .0156      | .0043      | .33       | .0028       | .0000     | .2544            | 0.7       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 0.09 | 2.64 | 1.06 | .0058 | .0212 | -     | -     | .30 | .0018 | -     | -     | -   |
| - | 1888  | - | - | 0.15 | 2.66 | 0.95 | .0069 | .0248 | -     | -     | .29 | .0065 | .0001 | -     | -   |
| - | 1889  | - | - | 0.11 | 2.43 | 0.78 | .0025 | .0196 | .0172 | .0024 | .30 | .0070 | .0001 | -     | -   |
| - | 1890  | - | - | 0.05 | 2.59 | 0.99 | .0015 | .0180 | .0147 | .0033 | .30 | .0075 | .0000 | -     | 1.0 |
| - | 1891  | - | - | 0.06 | 2.48 | 0.97 | .0014 | .0166 | .0140 | .0026 | .26 | .0075 | .0000 | -     | 0.7 |
| - | 1892  | - | - | 0.07 | 2.88 | 1.24 | .0019 | .0219 | .0172 | .0047 | .32 | .0067 | .0000 | -     | 0.7 |
| - | 1893  | - | - | 0.07 | 2.62 | 1.08 | .0052 | .0199 | .0156 | .0043 | .33 | .0028 | .0000 | .2544 | 0.7 |

\* June to December.

NOTE to analyses of 1893: Iron, .0057. Odor of the first sample, faintly vegetable, becoming faintly oily on standing or on heating; of the second sample, faintly vegetable, becoming strongly oily on heating; of the third sample, none, becoming faintly oily on heating; of the remaining samples, generally faintly vegetable, frequently none, rarely mouldy or grassy. — The samples were collected from the pond generally from five to eleven feet beneath the surface.

## NORWOOD.

*Microscopical Examination of Water from Buckmaster Pond, Dedham.*

[Number of organisms per cubic centimeter.]

|                         | 1893. |      |      |      |       |       |       |       |       |       |       |       |       |       |
|-------------------------|-------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                         | Jan.  | Jan. | Jan. | Feb. | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, .   | 17    | 19   | 26   | 9    | 7     | 7     | 12    | 6     | 6     | 10    | 8     | 4     | 8     | 7     |
| Number of sample, .     | 9884  | 9891 | 9933 | 9985 | 10078 | 10211 | 10384 | 10479 | 10597 | 10750 | 10970 | 11134 | 11291 | 11448 |
| PLANTS.                 |       |      |      |      |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . .         | 58    | 0    | 21   | pr.  | 8     | 63    | 39    | 917   | 20    | 5     | 40    | 151   | 138   | 26    |
| Asterionella, . .       | 14    | 0    | 15   | 0    | 8     | 50    | 34    | 228   | 0     | 0     | 31    | 133   | 108   | 21    |
| Cyclotella, . .         | 2     | 0    | 0    | 0    | 0     | 1     | 2     | 610   | 20    | 2     | 2     | 0     | 5     | 3     |
| Melosira, . .           | 0     | 0    | 0    | 0    | 0     | 2     | 0     | 0     | 0     | 0     | 6     | 15    | 23    | 0     |
| Synedra, . .            | 1     | 0    | 4    | 0    | 0     | 9     | pr.   | 1     | pr.   | 1     | 1     | 1     | 1     | 2     |
| Tabellaria, . .         | 41    | 0    | 2    | pr.  | 0     | 1     | 3     | 78    | 0     | 2     | 0     | 2     | 1     | pr.   |
| Cyanophyceæ, .          | 0     | 0    | 0    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 3     | 12    | 47    | 0     |
| Chroococcus, . .        | 0     | 0    | 0    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 12    | 7     | 0     |
| Microcystis, . .        | 0     | 0    | 0    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 3     | 0     | 40    | 0     |
| Algæ, . . . .           | 0     | 0    | 0    | 0    | 0     | 0     | 4     | 57    | 5     | 56    | 9     | 0     | 97    | 0     |
| Protooccus, . .         | 0     | 0    | 0    | 0    | 0     | 0     | 2     | 57    | 5     | 56    | 5     | 0     | 84    | 0     |
| Raphidium, . .          | 0     | 0    | 0    | 0    | 0     | 0     | 2     | 0     | 0     | 0     | 4     | 0     | 13    | 0     |
| ANIMALS.                |       |      |      |      |       |       |       |       |       |       |       |       |       |       |
| Rhizopoda, Diffugia,    | 0     | 0    | 0    | 0    | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 8     | pr.   |
| Infusoria, . . .        | 40    | 0    | 3    | 0    | 1     | pr.   | pr.   | pr.   | 3     | 104   | 20    | 1     | 1,003 | 48    |
| Dinobryon cases, .      | 38    | 0    | 3    | 0    | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1,000 | 48    |
| Peridinium, . .         | pr.   | 0    | 0    | 0    | 0     | pr.   | pr.   | pr.   | 3     | 104   | 20    | 0     | pr.   | pr.   |
| Trachelomonas, .        | pr.   | 0    | 0    | 0    | 0     | pr.   | 0     | pr.   | 0     | 0     | 0     | 1     | 3     | 0     |
| Uroglena, . . .         | 2     | 0    | 0    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | .02   | 0     |
| Vermes, Anurea, .       | pr.   | 0    | 0    | 0    | 0     | 0     | 0     | pr.   | pr.   | 0     | 0     | 0     | pr.   | 0     |
| Miscellaneous, Zoöglæa, | 0     | 0    | 0    | 0    | 8     | 3     | 24    | 22    | 12    | 40    | 52    | 144   | 22    | 3     |
| TOTAL, . . . .          | 98    | 0    | 24   | pr.  | 18    | 66    | 67    | 996   | 40    | 205   | 124   | 308   | 1,315 | 77    |

## NORWOOD.

*Chemical Examination of Water from Faucets in Norwood, supplied from Buckmaster Pond.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                    |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. |           |
|---------|---------------------|-------------|--------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.          | Color. | Total.                  | Loss on ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. | Oxygen Consumed. | Hardness. |
|         |                     |             |                    |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 9883    | 1893.<br>Jan. 16    | None.       | Slight,<br>earthy. | 0.05   | 2.85                    | 1.20              | .0080    | .0176       | .0154      | .0022      | .40       | .0000       | .0000     | .2372            | 0.6       |
| 9890    | -                   | V. slight.  | V. slight.         | 0.05   | -                       | -                 | -        | -           | -          | -          | -         | -           | -         | -                | -         |
| 9934    | Jan. 25             | V. slight.  | None.              | 0.10   | -                       | -                 | -        | -           | -          | -          | -         | -           | -         | -                | -         |
| 9986    | Feb. 8              | None.       | None.              | 0.05   | 2.60                    | 0.75              | .0080    | .0172       | .0154      | .0018      | .43       | .0050       | .0000     | .2263            | 1.1       |

Iron, .0145. Odor of the first sample, faintly vegetable, becoming distinctly vegetable and oily on heating; of the remaining samples, none, becoming faintly vegetable on heating.

*Microscopical Examination of Water from Faucets in the Village of Norwood, supplied from Buckmaster Pond.*

[Number of organisms per cubic centimeter.]

|                               | 1893.    |          |          |           |
|-------------------------------|----------|----------|----------|-----------|
|                               | January. | January. | January. | February. |
| Day of examination, . . . . . | 17       | 19       | 26       | 9         |
| Number of sample, . . . . .   | 9883     | 9890     | 9934     | 9986      |
| PLANTS.                       |          |          |          |           |
| Diatomaceæ, . . . . .         | 14       | 0        | 3        | 0         |
| Asterionella, . . . . .       | 7        | 0        | 3        | 0         |
| Cyclotella, . . . . .         | 3        | 0        | pr.      | 0         |
| Tabellaria, . . . . .         | 4        | 0        | 0        | 0         |
| ANIMALS.                      |          |          |          |           |
| Infusoria, . . . . .          | 40       | 2        | 0        | 0         |
| Dinobryon cases, . . . . .    | 40       | 0        | 0        | 0         |
| Uroglena, . . . . .           | 0        | 2        | 0        | 0         |
| TOTAL, . . . . .              | 54       | 2        | 3        | 0         |



## NEW BEDFORD.

*Chemical Examination of Water from Little Quittacas Pond, Lakeville.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.           |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-----------------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.            | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                       |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 14193   | 1895.<br>Apr. 22    | Slight.               | Cons.,<br>white.  | .17    | 3.15                            | 1.30                 | .0000    | .0142       | .0128      | .0014           | .51       | .0000          | .0000     | .3752            | 0.8       |
| 14987   | Sept. 4             | Slight.               | Slight.           | .15    | 3.15                            | 1.20                 | .0008    | .0196       | .0154      | .0042           | .56       | .0080          | .0000     | .2911            | 0.8       |
| 15821   | Dec. 30             | V. slight,<br>clayey. | Slight,<br>brown. | .22    | 3.20                            | 1.25                 | .0016    | .0150       | .0130      | .0020           | .47       | .0030          | .0000     | .2733            | 0.5       |
| Av.     | .....               | .....                 | .....             | .18    | 3.17                            | 1.25                 | .0008    | .0162       | .0137      | .0025           | .51       | .0037          | .0000     | .3132            | 0.7       |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | .23 | 2.92 | 1.16 | .0003 | .0149 | -     | -     | .51 | .0035 | -     | -     | -   |
| - | 1888† | - | - | .15 | 3.00 | 1.15 | .0003 | .0171 | -     | -     | .48 | .0035 | .0001 | -     | -   |
| - | 1893  | - | - | .11 | 3.02 | 1.23 | .0015 | .0150 | .0128 | .0023 | .48 | .0025 | .0000 | .2904 | 0.6 |
| - | 1894  | - | - | .18 | 2.91 | 0.95 | .0002 | .0155 | .0137 | .0023 | .48 | .0008 | .0000 | .3074 | 0.7 |
| - | 1895  | - | - | .18 | 3.17 | 1.25 | .0008 | .0162 | .0137 | .0025 | .51 | .0037 | .0000 | .3132 | 0.7 |

\* June and September.

† January and May.

NOTE to analyses of 1895: Odor, vegetable. — The samples were collected from the pond.

*Microscopical Examination of Water from Little Quittacas Pond, Lakeville.*

[Number of organisms per cubic centimeter.]

|                                   |  |  |  |  |  | 1895.  |            | 1896.    |
|-----------------------------------|--|--|--|--|--|--------|------------|----------|
|                                   |  |  |  |  |  | April. | September. | January. |
| Day of examination, . . . . .     |  |  |  |  |  | 23     | 7          | 2        |
| Number of sample, . . . . .       |  |  |  |  |  | 14193  | 14987      | 15821    |
| PLANTS.                           |  |  |  |  |  |        |            |          |
| Diatomaceæ, . . . . .             |  |  |  |  |  | 102    | 6          | 5        |
| Asterionella, . . . . .           |  |  |  |  |  | 57     | 0          | 0        |
| Cyclotella, . . . . .             |  |  |  |  |  | 11     | 3          | 0        |
| Synedra, . . . . .                |  |  |  |  |  | 34     | 3          | 5        |
| Cyanophyceæ, . . . . .            |  |  |  |  |  | 0      | 96         | 0        |
| Chroococcus, . . . . .            |  |  |  |  |  | 0      | 9          | 0        |
| Merismopedia, . . . . .           |  |  |  |  |  | 0      | 89         | 0        |
| Algæ, . . . . .                   |  |  |  |  |  | 3      | 82         | 6        |
| Protococcus, . . . . .            |  |  |  |  |  | 0      | 82         | 0        |
| Zoospores, . . . . .              |  |  |  |  |  | 3      | 0          | 0        |
| ANIMALS.                          |  |  |  |  |  |        |            |          |
| Infusoria, . . . . .              |  |  |  |  |  | 32     | 1          | 8        |
| Dinobryon, . . . . .              |  |  |  |  |  | 22     | 0          | 0        |
| Dinobryon cases, . . . . .        |  |  |  |  |  | 9      | 0          | 0        |
| Peridinium, . . . . .             |  |  |  |  |  | 1      | 0          | 0        |
| Trachelomonas, . . . . .          |  |  |  |  |  | 0      | 1          | 0        |
| Crustacea, Cyclops, . . . . .     |  |  |  |  |  | .12    | 0          | 0        |
| Miscellaneous, Zoöglæa, . . . . . |  |  |  |  |  | 11     | 0          | 20       |
| TOTAL, . . . . .                  |  |  |  |  |  | 148    | 187        | 25       |

## ORANGE.

factory than that from other portions of the works, and to use the surplus water not needed for the supply of the town to furnish power for pumping; but an auxiliary steam plant has been provided at the pumping station for use at times when the supply of water is insufficient to furnish the power needed.

Coolidge Brook is a small tributary of Miller's River from the south which joins the river at a point about one and one-half miles below the village of Orange. The collecting reservoir is located just above the point where the brook is crossed by the Holshire road, about one and three-quarters miles from its mouth. The drainage area of the brook at this point is estimated to be about 1.38 square miles. The reservoir covers an area of about 0.72 acre, and it is said to have a capacity of 2,045,000 gallons when filled to the crest of the overflow, which is three feet below the top of the dam. The loam and sub-soil are said to have been removed from all of the area flowed. The water which passes the overflow is conveyed through a 48-inch pipe two hundred and fifty feet in length and discharged into North Pond.

Provision has been made for filtering the water drawn from Coolidge Brook for the supply of the town, by constructing on the up-stream side of the dam a rectangular filter-chamber of rubble masonry, 10 feet long, 7.5 feet wide, and of a height equal to that of the dam. The filter, which is on the up-stream side, is 5 feet 6 inches in width and of the same height as the walls of the chamber; the filtering material, consisting of sand or gravel, is four feet in thickness, and is retained between perforated wooden planks lined with copper wire screens.

It is the intention to have the top of the chamber closed tightly in order that water may be run back through it under pressure so as to wash the filter. All matter forced out of the filter in this way will mingle with the water in the reservoir. A 10-inch waste pipe is laid beneath the dam to provide for emptying the reservoir when necessary, and to waste the dirty water at times when the filter is being cleaned.

North Pond is located at the head of the middle branch of the Swift River, and originally had an area of about sixty acres. The area and storage capacity of the pond have been greatly increased by the construction of two dams, raising the surface of the pond to

**ORANGE.**

a level ten feet above the former high-water mark. One of the dams is located at the natural outlet of the pond, and the other at the northerly end at a low place in the divide between the Swift and Miller's rivers, over which water would otherwise pass into Coolidge Brook.

The present area of the pond at high water is 132 acres, and the increase in its storage capacity, obtained by raising the level ten feet, is said to amount to 357,000,000 gallons. The drainage area of the pond, including water surfaces and exclusive of Coolidge Brook, is estimated to be 0.66 of a square mile. By increasing the height of the water in the pond, a considerable area of swamp land has been flooded, which was prepared for flowage only by the removal of the trees.

Water from North Pond is drawn through a canal, the bottom of which at its upper end is about 11.41 feet below high-water mark, to Coolidge Brook, and flows in the channel of the brook to the Greenhalge Reservoir, at a distance of a little less than a mile from the pond.

Greenhalge Reservoir covers an area of about 1.9 acres and is said to have a capacity of 1,058,000 gallons. It was originally a mill pond, and after its purchase by the town was enlarged by the construction of a new and higher dam.

The pumping station is located in the valley of the brook just below the Greenhalge Reservoir, and from this point water is pumped to a distributing reservoir situated on Walnut Hill, about a mile south-west of the village of Orange and between it and the pumping station.

The distributing reservoir has the form of a rectangle, except that one end is semi-circular; it is 162 feet 6 inches in length by 80 feet in width on the bottom, and 20 feet in depth from the top of the embankment. When filled to high-water mark, which is five feet below the level of the embankment, it contains 2,125,000 gallons. The slopes are lined with clay puddle four feet in thickness, covered with a six-inch layer of broken stone, upon which is laid a stone paving one foot in thickness. The bottom is also of puddle four feet in thickness, covered with a six-inch layer of broken stone. Water enters the reservoir through a pipe laid along its bottom, and is drawn out at the opposite end. Provision has been made

## ORANGE.

for shutting off the reservoir from the rest of the system and pumping water directly to the town if necessary. The distributing mains are of cast iron; service pipes are of galvanized iron.

*Chemical Examination of Water from Coolidge Brook, Orange.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 11396   | 1893.<br>Nov. 27    | None.       | V. slight. | 0.33   | 3.80                    | 0.80              | .0044    | .0140       | .0108      | .0032      | .12       | .0070       | .0002     | .4300            | 1.2       |

Iron, .0150. Odor, very faintly vegetable. — The sample was collected from a faucet in Orange, supplied from Coolidge Brook.

*Microscopical Examination.*

Miscellaneous, Zoöglæa, 1.

*Chemical Examination of Water from North Pond, Orange.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 11397   | 1893.<br>Nov. 27    | Slight.     | Cons.     | 0.12   | 2.60                    | 0.75              | .0022    | .0208       | .0152      | .0056      | .18       | .0070       | .0001     | .3655            | 1.3       |

Iron, .0140. Odor, very faintly vegetable. — The sample was collected from the pond.

*Microscopical Examination.*

Diatomaceæ, *Asterionella*, 94; *Cocconeia*, 1; *Cyclotella*, 13; *Diatoma*, 1; *Epithemia*, 1; *Gyrodinium*, 1; *Melosira*, 292; *Meridion*, 1; *Synedra*, 5; *Tabellaria*, 14. Cyanophyceæ, *Merismopedia*, 10. Algæ, *Conserva*, 1; *Cosmarium*, 1; *Protococcus*, 20; *Raphidium*, 10; *Staurastrum*, 3. Infusoria, *Dinobryon* cases, 3. Vermes, *Anurea*, 1. Crustacea, *Daphnia*, .01. Miscellaneous, Zoöglæa, 84. Total, 556.

**PALMER.****WATER SUPPLY OF PALMER FIRE DISTRICT, PALMER. — PALMER WATER COMPANY.***Chemical Examination of Water from the Works of the Palmer Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |           |
| 1893.   |                     |             |           |        |                         |                   |          |             |            |                 |           |             |           |                  |           |
| 10535   | June 20             | Distinct.   | Cons.     | 0.30   | 3.35                    | 1.00              | .0004    | .0134       | .0070      | .0064           | .10       | .0000       | .0000     | .2345            | 0.9       |
| 10971   | Sept. 6             | Slight.     | Cons.     | 0.25   | 4.10                    | 1.30              | .0002    | .0188       | .0134      | .0054           | .15       | .0000       | .0001     | .3920            | 1.3       |

Iron in the first sample, .0235; in the last, .0650. Odor, none. On heating, the odor of the first sample became very faintly vegetable, and of the last decidedly sweetish (grassy). — The first sample was collected from a faucet in the town; the last, from the reservoir.

*Microscopical Examination.*

No. 10535. Diatomaceæ, *Diatoma*, 116; *Gomphonema*, 4; *Melosira*, 6; *Navicula*, 1; *Synedra*, 116; *Tabellaria*, 1. Cyanophyceæ, *Merismopedia*, 26. Algæ, *Conferæ*, 2; *Cosmarium*, 1; *Glacocapsa*, 8; *Pediastrum*, 2; *Scenedesmus*, 1; *Clothrix*, 1; *Zoospores*, 1. Infusoria, *Peridinium*, 24. Miscellaneous, *Zoëglæa*, 84. Total, 394.

No. 10971. Diatomaceæ, *Cocconeina*, 1; *Cyclotella*, 1; *Diatoma*, 6; *Melosira*, 24; *Synedra*, 24; *Tabellaria*, 3. Algæ, *Cosmarium*, 1; *Pediastrum*, 3; *Scenedesmus*, 1. Fungi, *Orenothrix*, 2. Infusoria, *Dinobryon cases*, 108; *Peridinium*, 72. Vermes, *Polyarthra*, 1. Miscellaneous, *Zoëglæa*, 64. Total, 311.

**PEMBROKE.***Chemical Examination of Water from Little Sandy, Stetson's, Oldham and Furnace Ponds and Silver Lake, Pembroke.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1893.   |                     |             |            |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 10330   | Apr. 29             | -           | -          | 0.02   | -                       | -                 | -        | -           | -          | -          | .58       | -           | -         | -                | -         |
| 10331   | Apr. 29             | -           | -          | 0.40   | -                       | -                 | -        | -           | -          | -          | .48       | -           | -         | -                | -         |
| 10335   | Apr. 29             | V. slight.  | V. slight. | 0.30   | 3.35                    | 1.25              | .0000    | .0180       | .0142      | .0038      | .59       | .0030       | .0000     | .4234            | 0.9       |
| 10336   | Apr. 29             | V. slight.  | Cons.      | 0.30   | 3.65                    | 1.45              | .0010    | .0188       | .0150      | .0038      | .58       | .0030       | .0000     | .4672            | 0.8       |
| 10337   | Apr. 29             | V. slight.  | V. slight. | 0.05   | 2.75                    | 0.50              | .0000    | .0102       | .0064      | .0038      | .62       | .0030       | .0000     | .2190            | 0.8       |

Iron in the first two samples, not determined; in the third, .0065; in the fourth, .0050; in the last, none. Odor of No. 10335, distinctly vegetable; of No. 10336, faintly vegetable, becoming stronger on heating; of No. 10337, none, becoming very faintly vegetable on heating. — The samples were collected as follows: No. 10330, from Little Sandy Pond at upper end, near road; No. 10331, from Stetson's Pond near its outlet; No. 10335, from the brook flowing from Oldham Pond into Furnace Pond; No. 10336, from Furnace Pond near its outlet; No. 10337, from Silver Lake, north-westerly side, near shore.

The samples were collected in connection with an investigation for an additional water supply for Whitman.

## PEMBROKE.

*Microscopical Examination of Water from Little Sandy, Stetson's, Oldham and Furnace Ponds and Silver Lake, Pembroke.*

[Number of organisms per cubic centimeter.]

|                                   | 1892. |       |       |       |       |
|-----------------------------------|-------|-------|-------|-------|-------|
|                                   | May.  | May.  | May.  | May.  | May.  |
| Day of examination, . . . . .     | 1     | 1     | 1     | 1     | 1     |
| Number of sample, . . . . .       | 10330 | 10331 | 10335 | 10336 | 10337 |
| PLANTS.                           |       |       |       |       |       |
| Diatomaceæ, . . . . .             | 110   | 111   | 21    | 20    | 195   |
| Asterionella, . . . . .           | 2     | 76    | 2     | 5     | 19    |
| Cocconeis, . . . . .              | 0     | 0     | 0     | 1     | 0     |
| Cocconeia, . . . . .              | 0     | 0     | 0     | 1     | 0     |
| Coscinodiscus, . . . . .          | 0     | 1     | 0     | 0     | 0     |
| Cyclotella, . . . . .             | 0     | 32    | 0     | 1     | 6     |
| Fragilaria, . . . . .             | 2     | 0     | 0     | 0     | 0     |
| Grammatophora, . . . . .          | 0     | 0     | 0     | 1     | 0     |
| Melosira, . . . . .               | 0     | 0     | 0     | 0     | 164   |
| Navicula, . . . . .               | 2     | 0     | 0     | 1     | 1     |
| Pleurosigma, . . . . .            | 2     | 0     | 0     | 0     | 0     |
| Stephanodiscus, . . . . .         | 0     | 0     | 0     | 0     | 1     |
| Synedra, . . . . .                | 100   | 0     | 11    | 7     | 2     |
| Tabellaria, . . . . .             | 2     | 2     | 8     | 3     | 2     |
| Cyanophyceæ, Nostoc, . . . . .    | 1     | 0     | 0     | 0     | 0     |
| Algeæ, . . . . .                  | 295   | 1     | 1     | 64    | 0     |
| Chlorococcus, . . . . .           | 2     | 0     | 1     | 5     | 0     |
| Dictyosphaerium, . . . . .        | 0     | 0     | 0     | 16    | 0     |
| Nephrocylum, . . . . .            | 0     | 0     | 0     | 6     | 0     |
| Protococcus, . . . . .            | 0     | 0     | 0     | 36    | 0     |
| Scenedesmus, . . . . .            | 1     | 0     | 0     | 0     | 0     |
| Staurostrum, . . . . .            | 0     | 1     | 0     | 0     | 0     |
| Zoospores, . . . . .              | 292   | 0     | 0     | 1     | 0     |
| Fungi, Crenothrix, . . . . .      | 0     | 0     | 0     | 3     | 0     |
| ANIMALS.                          |       |       |       |       |       |
| Rhizopoda, Actinophrys, . . . . . | 0     | 0     | 1     | 0     | 0     |
| Infusoria, . . . . .              | 69    | 1     | 4     | 3     | 0     |
| Dinobryon, . . . . .              | 0     | 0     | 0     | 1     | 0     |
| Dinobryon cases, . . . . .        | 6     | 1     | 2     | 0     | 0     |
| Encysted Protozoa, . . . . .      | 60    | 0     | 0     | 0     | 0     |
| Monas, . . . . .                  | 0     | 0     | 1     | 0     | 0     |
| Peridinium, . . . . .             | 3     | 0     | 1     | 2     | 0     |
| Vermes, . . . . .                 | 3     | 2     | 1     | 1     | 0     |
| Anurea, . . . . .                 | 3     | 1     | 1     | 1     | 0     |
| Monocerca, . . . . .              | 0     | 1     | 0     | 0     | 0     |
| Crustacea, Cyclops, . . . . .     | 0     | 0     | 0     | .06   | 0     |
| Miscellaneous, Zoöglæa, . . . . . | 152   | 10    | 12    | 88    | 0     |
| TOTAL, . . . . .                  | 630   | 125   | 40    | 179   | 195   |

## PLYMOUTH.

## WATER SUPPLY OF PLYMOUTH.

In the early part of 1893 the organism *Uroglena*, which was present in considerable numbers in 1892, made its appearance in the water of Little South Pond, and was very abundant in the first part of February. It had entirely disappeared by the end of March and is said not to have been noticed again during the remainder of the year. A description of this organism, and its effect upon the taste and odor of water, was given in the Twenty-third Annual Report of the State Board of Health, pages 645-658.

*Chemical Examination of Water from Little South Pond, Plymouth.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. |     | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. | Oxygen Consumed. |     |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |     |           |
| 1893.   |                     |             |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |     |           |
| 9968    | Feb. 6              | V. slight.  | V. slight. | 0.04   | 2.70                            | 0.60                 | .0014    | .0162       | .0142      | .0020           | .70       | .0070          | .0001     | .1131            | 0.9 |           |
| 10179   | Mar. 27             | V. slight.  | Slight.    | 0.00   | 1.90                            | 0.75                 | .0000    | .0094       | .0072      | .0022           | .59       | .0030          | .0000     | .0766            | 0.2 |           |

Iron, none. Odor of the first sample, distinctly oily, becoming decidedly oily on heating, and strongly oily after standing one day in the laboratory; of the last sample, none. — The samples were collected from the pond.

*Microscopical Examination.*

No. 9968. Infusoria, *Uroglena*, very abundant.

No. 10179. Miscellaneous, *Zoëglæa*, 4.

## WATER SUPPLY OF PROVINCETOWN.

Population in 1890, 4,624. The works are owned by the town, and were completed in 1893. The supply is taken from a system of six tubular wells located about three-fourths of a mile north of the centre of the village. The wells are five inches in diameter, average twenty-eight feet in depth, and are the same that were used during a pumping test made in 1892. The material in which the wells were sunk is loose sand, which, like other sand in this region, contains more or less organic matter. The extreme wells are about four hundred feet apart in an easterly and westerly direction, and two hundred feet in a northerly and southerly direction. Water from the wells is pumped to a covered iron tank twenty-eight feet in diameter and one hundred feet high, and is distributed thence to the town. In order to aerate the water, the force main is carried vertically up

## PROVINCETOWN.

inside the tank to its top, and is provided with a wide flange over which the water falls in a thin sheet. The distributing mains are of cast iron; service pipes of wrought iron lined with cement.

Extended references to the character of this water, which differs from other ground waters in the State, may be found in the annual report of the State Board of Health for 1892, pages 41-44 and 214-218.

*Chemical Examination of Water from the Tubular Wells of the Provincetown Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |                |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|--------------------|----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.         | Sediment.      | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 11266   | 1893.<br>Oct. 28    | Distinct, milky.   | Slight.        | 1.00   | 8.70                    | .0030    | .0082       | 1.99      | .0000       | .0000     | .8308            | 1.1       | .1200 |
| 11333   | Nov. 14             | Distinct, fibrous. | V. slight.     | 1.10   | 7.30                    | .0038    | .0088       | 2.36      | .0030       | .0000     | .7719            | 1.1       | .1100 |
| 11405   | Nov. 27             | Decided.           | Cons., rusty.  | 1.00   | 7.50                    | .0022    | .0092       | 2.03      | .0030       | .0002     | .7353            | 1.6       | .1560 |
| 11481   | Dec. 12             | Distinct.          | Slight, rusty. | 0.85   | 7.10                    | .0018    | .0066       | 1.95      | .0030       | .0000     | .6320            | 1.6       | .1500 |
| Av...   | .....               | .....              | .....          | 0.99   | 7.65                    | .0027    | .0082       | 2.08      | .0023       | .0001     | .7425            | 1.4       | .1340 |

Odor, of No. 11405, faintly vegetable; of the remaining samples none; on heating the odor of all the samples was faintly vegetable. — The samples were collected from a faucet at the pumping station.

*Microscopical Examination of Water from the Tubular Wells of the Provincetown Water Works.*

|                               | 1893.    |           |           |           |
|-------------------------------|----------|-----------|-----------|-----------|
|                               | October. | November. | November. | December. |
| Day of examination, . . . . . | 31       | 15        | 29        | 14        |
| Number of sample, . . . . .   | 11266    | 11333     | 11405     | 11481     |
| <b>ANIMALS.</b>               |          |           |           |           |
| Infusoria, Monas, . . . . .   | 0        | 1         | 0         | 1         |
| Miscellaneous, . . . . .      | 290      | 0         | 7         | 0         |
| Iron rust, . . . . .          | 260      | 0         | *         | *         |
| Zoöglas, . . . . .            | 30       | 0         | 7         | 0         |
| TOTAL, . . . . .              | 290      | 1         | 7*        | 1*        |

\* Iron rust very abundant.



## QUINCY.

## WATER SUPPLY OF QUINCY.

*Chemical Examination of Water from Town Brook just above the Storage Reservoir of the Quincy Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 9955    | 1898.<br>Jan. 30    | V. slight.  | Slight.    | 0.50   | 4.55                            | 1.45                 | .0044    | .0154       | .0134      | .0020           | .60       | .0290          | .0002     | .5227            | 1.4       |
| 10059   | Feb. 28             | None.       | V. slight. | 0.55   | 3.80                            | 1.20                 | .0000    | .0098       | .0080      | .0018           | .63       | .0300          | .0001     | .4860            | 1.1       |
| 10193   | Mar. 30             | Slight.     | Slight.    | 0.70   | 3.40                            | 1.25                 | .0032    | .0152       | .0136      | .0016           | .49       | .0100          | .0000     | .5256            | 0.5       |
| 10319   | Apr. 25             | V. slight.  | Slight.    | 0.75   | 3.55                            | 1.60                 | .0008    | .0148       | .0122      | .0026           | .51       | .0050          | .0000     | .6898            | 0.3       |
| 10450   | May 25              | V. slight.  | Slight.    | 2.00   | 4.25                            | 2.10                 | .0004    | .0272       | .0250      | .0022           | .51       | .0120          | .0000     | 1.2375           | 0.8       |
| 10561   | June 26             | V. slight.  | Slight.    | 1.90   | 5.20                            | 2.90                 | .0000    | .0300       | .0252      | .0048           | .46       | .0030          | .0000     | 1.4773           | 0.5       |
| 10697   | July 25             | V. slight.  | V. slight. | 0.70   | 4.45                            | 1.85                 | .0006    | .0164       | .0130      | .0034           | .53       | .0060          | .0002     | 1.2723           | 1.1       |
| 10899   | Aug. 28             | Slight.     | Slight.    | 1.00   | 5.05                            | 2.15                 | .0000    | .0150       | .0135      | .0015           | .60       | .0060          | .0001     | .7263            | 0.6       |
| 11248   | Oct. 23             | V. slight.  | Slight.    | 0.80   | 6.40                            | 2.10                 | .0008    | .0134       | .0086      | .0048           | .68       | .0150          | .0004     | .4104            | 0.9       |
| 11394   | Nov. 27             | None.       | V. slight. | 0.50   | 4.60                            | 1.00                 | .0056    | .0120       | .0076      | .0044           | .69       | .0050          | .0002     | .5375            | 1.3       |
| 11532   | Dec. 20             | V. slight.  | Slight.    | 0.85   | 4.55                            | 2.30                 | .0000    | .0160       | .0140      | .0020           | .56       | .0030          | .0000     | .8343            | 0.8       |
| Av.     | .....               | .....       | .....      | 0.93   | 4.53                            | 1.81                 | .0014    | .0168       | .0140      | .0023           | .57       | .0110          | .0001     | .7923            | 0.8       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 0.50 | 5.30 | 1.50 | .0000 | .0133 | -     | -     | .65 | .0080 | -     | -     | -   |
| - | 1888† | - | - | 0.45 | 3.64 | 1.05 | .0001 | .0122 | -     | -     | .54 | .0070 | .0003 | -     | -   |
| - | 1889  | - | - | 1.21 | 4.61 | 1.87 | .0013 | .0239 | .0203 | .0036 | .48 | .0073 | .0001 | -     | -   |
| - | 1890  | - | - | 0.73 | 5.22 | 2.17 | .0024 | .0187 | .0155 | .0032 | .52 | .0125 | .0002 | -     | 1.3 |
| - | 1891  | - | - | 0.72 | 4.22 | 1.50 | .0004 | .0156 | .0132 | .0024 | .49 | .0112 | .0001 | -     | 0.7 |
| - | 1892  | - | - | 0.37 | 4.57 | 1.56 | .0041 | .0191 | .0159 | .0032 | .55 | .0114 | .0001 | -     | 0.8 |
| - | 1893  | - | - | 0.93 | 4.53 | 1.81 | .0014 | .0168 | .0140 | .0023 | .57 | .0110 | .0001 | .7298 | 0.8 |

\* October.

† November and December.

NOTE to analyses of 1893; Iron, .0153. Odor, generally distinctly vegetable and often grassy or sweetish, becoming somewhat stronger on heating.—The samples were collected from the brook above the reservoir.

*Microscopical Examination.*

The greatest number of organisms per cubic centimeter found in any of the samples collected in 1893 was 198, in April; the smallest number, 1, in March; and the average, 62.

## QUINCY.

*Chemical Examination of Water from the Storage Reservoir, Quincy.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|--------------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.         | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                    |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 9956    | 1893.<br>Jan. 30    | V. slight.         | V. slight.        | 0.65   | 5.10                            | 1.90                 | .0140    | .0196       | .0172      | .0024           | .65       | .0300          | .0001     | .5475            | 1.7       |
| 10060   | Feb. 28             | None.              | V. slight.        | 0.50   | 4.00                            | 1.60                 | .0002    | .0102       | .0074      | .0028           | .65       | .0220          | .0000     | .5865            | 1.1       |
| 10194   | Mar. 30             | Slight.            | Slight.           | 0.30   | 3.30                            | 1.15                 | .0024    | .0130       | .0106      | .0024           | .53       | .0150          | .0001     | .3358            | 0.5       |
| 10818   | Apr. 25             | Slight.            | Cons.             | 0.45   | 3.60                            | 1.35                 | .0028    | .0148       | .0106      | .0042           | .52       | .0100          | .0000     | .4270            | 0.3       |
| 10451   | May 25              | Decided.           | Cons.             | 0.60   | 3.15                            | 1.60                 | .0004    | .0218       | .0184      | .0034           | .46       | .0180          | .0000     | .5512            | 0.6       |
| 10562   | June 26             | Decided.           | Cons.,<br>yellow. | 0.80   | 3.50                            | 1.25                 | .0010    | .0324       | .0224      | .0100           | .60       | .0060          | .0001     | .5727            | 0.9       |
| 10698   | July 25             | Distinct.          | Cons.,<br>green.  | 0.75   | 3.55                            | 1.50                 | .0000    | .0304       | .0248      | .0056           | .64       | .0030          | .0001     | .5032            | 0.9       |
| 10900   | Aug. 28             | Decided,<br>green. | Slight,<br>rusty. | 0.80   | 3.95                            | 1.90                 | .0014    | .0238       | .0186      | .0052           | .63       | .0000          | .0000     | .5609            | 0.6       |
| 11094   | Sept. 25            | Distinct.          | Cons.,<br>brown.  | 0.60   | 3.15                            | 1.25                 | .0000    | .0254       | .0218      | .0036           | .63       | .0030          | .0001     | .5658            | 0.6       |
| 11249   | Oct. 23             | Distinct.          | Cons.,<br>green.  | 0.43   | 4.70                            | 2.05                 | .0026    | .0244       | .0178      | .0066           | .66       | .0050          | .0001     | .3724            | 0.8       |
| 11395   | Nov. 27             | Distinct.          | Slight.           | 0.48   | 3.80                            | 1.25                 | .0240    | .0276       | .0214      | .0062           | .69       | .0050          | .0003     | .5031            | 0.6       |
| 11533   | Dec. 20             | Slight,<br>clayey. | Slight.           | 0.40   | 3.95                            | 1.35                 | .0140    | .0178       | .0150      | .0028           | .65       | .0090          | .0001     | .5362            | 0.5       |
| Av..    | .....               | .....              | .....             | 0.56   | 3.81                            | 1.51                 | .0052    | .0218       | .0172      | .0046           | .61       | .0104          | .0001     | .5052            | 0.8       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1888* | - | - | 0.50 | 3.95 | 1.13 | .0030 | .0178 | .0132 | .0046 | .68 | .0150 | .0003 | -     | -   |
| - | 1889  | - | - | 0.92 | 3.76 | 1.19 | .0116 | .0303 | .0238 | .0065 | .53 | .0087 | .0003 | -     | -   |
| - | 1890  | - | - | 0.70 | 4.56 | 1.76 | .0085 | .0249 | .0178 | .0071 | .54 | .0166 | .0002 | -     | 1.3 |
| - | 1891  | - | - | 0.70 | 3.97 | 1.60 | .0027 | .0274 | .0178 | .0066 | .50 | .0100 | .0000 | -     | 0.7 |
| - | 1892  | - | - | 0.62 | 4.07 | 1.41 | .0051 | .0237 | .0175 | .0062 | .61 | .0098 | .0001 | -     | 0.9 |
| - | 1893  | - | - | 0.56 | 3.81 | 1.51 | .0052 | .0218 | .0172 | .0046 | .61 | .0104 | .0001 | .5052 | 0.8 |

\* November and December.

NOTE to analyses of 1893; Iron, .0265. Odor, vegetable and occasionally unpleasant or mouldy, becoming somewhat stronger on heating. — The samples were collected from the reservoir near the surface in the vicinity of the gate-house. Many dead fish came ashore in June.

## NORTHAMPTON.

*Chemical Examination of Water from Roberts' Meadow Brook, just above the Middle Reservoir of the Northampton Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 14759   | 1895.<br>Aug. 1     | V. slight.  | Slight.    | .40    | 5.25                            | 1.50                 | .0008    | .0140       | .0132      | .0008           | .14       | .0050          | .0000     | .6064            | 3.1       |
| 14927   | Aug. 27             | None.       | V. slight. | .28    | 5.70                            | 1.70                 | .0004    | .0108       | .0088      | .0020           | .14       | .0050          | .0003     | .2806            | 1.5       |
| 15210   | Sept. 17            | V. slight.  | Slight.    | .17    | 4.55                            | 0.90                 | .0004    | .0078       | .0054      | .0024           | .15       | .0030          | .0000     | .1854            | 2.2       |
| 15417   | Oct. 22             | V. slight.  | Slight.    | .35    | 5.05                            | 1.65                 | .0002    | .0132       | .0110      | .0022           | .16       | .0030          | .0002     | .4992            | 2.1       |
| 15642   | Nov. 29             | None.       | V. slight. | .49    | 3.75                            | 1.35                 | .0000    | .0104       | .0074      | .0030           | .14       | .0000          | .0000     | .5343            | 1.3       |
| 15818   | Dec. 28             | Slight.     | Slight.    | .50    | 4.00                            | 1.65                 | .0010    | .0232       | .0216      | .0016           | .12       | .0030          | .0000     | .8867            | 1.1       |
| Av.     | .....               | .....       | .....      | .36    | 4.72                            | 1.46                 | .0005    | .0132       | .0112      | .0020           | .14       | .0032          | .0001     | .4492            | 1.9       |

Odor, faintly vegetable or none, generally somewhat stronger on heating. — The samples were collected from the stream, just above the reservoir.

*Microscopical Examination of Water from Roberts' Meadow Brook, just above the Middle Reservoir of the Northampton Water Works.*

[Number of organisms per cubic centimeter.]

|                                   | 1895. |       |       |       |       |       |
|-----------------------------------|-------|-------|-------|-------|-------|-------|
|                                   | Aug.  | Aug.  | Sept. | Oct.  | Dec.  | Dec.  |
| Day of examination, . . . . .     | 6     | 30    | -     | 25    | 2     | 31    |
| Number of sample, . . . . .       | 14759 | 14927 | 15210 | 15417 | 15642 | 15818 |
| PLANTS.                           |       |       |       |       |       |       |
| Diatomaceæ, . . . . .             | 31    | 520   | -     | 0     | 1     | 0     |
| Cyclotella, . . . . .             | 6     | 520   | -     | 0     | 0     | 0     |
| Navicula, . . . . .               | 5     | 0     | -     | 0     | 0     | 0     |
| Pinnularia, . . . . .             | 5     | 0     | -     | 0     | 0     | 0     |
| Synedra, . . . . .                | 15    | 0     | -     | 0     | 1     | 0     |
| Algae, Raphidium, . . . . .       | 12    | 0     | -     | 0     | 0     | 0     |
| Fungi, Crenothrix, . . . . .      | 4     | 48    | -     | 92    | 2     | 1     |
| Miscellaneous, Zoögloæ, . . . . . | 0     | 0     | -     | 6     | 0     | 10    |
| TOTAL, . . . . .                  | 47    | 568   | -     | 98    | 3     | 11    |

## QUINCY.

*Chemical Examination of Water from the Surface and from near the Bottom of the Quincy Storage Reservoir.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed, |           |
|---------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. | Oxygen Consumed, | Hardness. |
|         |                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 10499   | 1893.<br>June 8     | Distinct.   | Cons.     | 0.60   | 3.65                            | 1.60                 | .0000    | .0232       | .0186      | .0046           | .69       | .0030          | .0002     | .4924            | 0.3       |
| 10500   | June 8              | Distinct.   | Cons.     | 0.80   | 4.00                            | 1.60                 | .0342    | .0260       | .0162      | .0098           | .58       | .0050          | .0012     | .4321            | 0.6       |

Iron in the first sample, .0115; in the second sample, .0500. Odor, faintly vegetable, becoming much stronger on heating.—The samples were collected from the reservoir about fifty feet from the gate-house at a point where the water was about thirty feet deep; the first sample was collected near the surface and the last near the bottom.

*Microscopical Examination.*

No. 10499. Diatomaceæ, *Asterionella*, 16; *Tabellaria*, 240. Cyanophyceæ, *Clathrocystis*, 22; *Oscosphaerium*, 1. Algæ, *Chlorococcus*, 5; *Pediastrum*, 1; *Scenedesmus*, 1; *Staurastrum*, 1; *Zoöspores*, 1. Infusoria, *Dinobryon cases*, 14; *Monas*, 1; *Peridinium*, 2; *Synura*, 7; *Vorticella*, 8. Miscellaneous, *Zoöglæa*, 7. Total, 327.

No. 10500. Diatomaceæ, *Tabellaria*, 4. Fungi, *Orenothrix*, 3. Infusoria, *Dinobryon cases*, 4; *Monas*, 1. Miscellaneous, *Zoöglæa*, 58. Total, 70.

*Table showing Heights of Water in the Storage Reservoir of the Quincy Water Works on Dates when Samples of Water were collected for Analysis.*

[High-water mark is 86.71 feet above city base.]

| 1893.     |   |   |   | Heights above City Base. | 1892.     |   |   |   | Heights above City Base. |
|-----------|---|---|---|--------------------------|-----------|---|---|---|--------------------------|
| Jan. 30,  | . | . | . | Feet. 83.71              | Aug. 28,  | . | . | . | 83.46                    |
| Feb. 28,  | . | . | . | 86.79                    | Sept. 25, | . | . | . | 81.59                    |
| Mar. 30,  | . | . | . | 86.92                    | Oct. 23,  | . | . | . | 79.85                    |
| April 25, | . | . | . | 86.79                    | Nov. 27,  | . | . | . | 79.71                    |
| June 26,  | . | . | . | 86.65                    | Dec. 20,  | . | . | . | 81.09                    |
| July 25,  | . | . | . | 84.53                    |           |   |   |   |                          |

## RANDOLPH AND HOLBROOK.

## WATER SUPPLY OF RANDOLPH AND HOLBROOK.

*Chemical Examination of Water from Great Pond in Randolph and Braintree.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1893.   |                     |             |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 9932    | Jan. 24             | Slight.     | None.      | 0.60   | 4.80                            | 1.55                 | .0068    | .0416       | .0278      | .0138           | .69       | .0030          | .0000     | .6351            | 1.7       |
| 10298   | Apr. 24             | V. slight.  | V. slight. | 0.55   | 3.65                            | 1.10                 | .0000    | .0116       | .0098      | .0018           | .54       | .0090          | .0001     | .4562            | 0.8       |
| 10699   | July 25             | V. slight.  | None.      | 0.38   | 4.15                            | 1.80                 | .0000    | .0189       | .0156      | .0030           | .50       | .0050          | .0000     | .4366            | 1.1       |
| 11252   | Oct. 25             | V. slight.  | V. slight. | 0.40   | 6.80                            | 2.90                 | .0000    | .0184       | .0172      | .0012           | .60       | .0030          | .0000     | .4940            | 0.9       |
| Av.     | .....               | .....       | .....      | 0.48   | 4.73                            | 1.84                 | .0017    | .0226       | .0176      | .0050           | .58       | .0050          | .0000     | .5055            | 1.1       |

Iron, .0090. Odor of the first two samples distinctly vegetable; of the last two, faintly vegetable. — The first sample was collected directly from Great Pond, the remaining samples from faucets in Randolph and Holbrook.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in these samples varied from none to 23 and averaged 7.

## WATER SUPPLY OF READING.

*Chemical Examination of Water from the Filter-gallery of the Reading Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.             |                |        | Residue on Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------------------|----------------|--------|-------------------------|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.              | Sediment.      | Color. |                         | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         |                     |                         |                |        |                         |          |                  |           |             |           |                  |           |       |
| 1893.   |                     |                         |                |        |                         |          |                  |           |             |           |                  |           |       |
| 9869    | Jan. 10             | Decided, milky.         | Heavy, rusty.  | 0.50   | 9.30                    | .0046    | .0056            | .52       | .0120       | .0000     | .3920            | 3.5       | .1250 |
| 9984    | Feb. 7              | Distinct.               | Cons., rusty.  | 0.65   | 8.60                    | .0036    | .0134            | .52       | .0050       | .0000     | .4599            | 3.1       | .0925 |
| 10082   | Mar. 5              | Decided.                | Cons.          | 0.60   | 8.80                    | .0038    | .0086            | .54       | .0120       | .0000     | .3744            | 3.8       | .1700 |
| 10225   | Apr. 10             | Slight.                 | V. slight.     | 0.75   | 7.10                    | .0032    | .0076            | .47       | .0030       | .0002     | .3832            | 2.6       | .0525 |
| 10377   | May 10              | Distinct, milky.        | Slight, rusty. | 1.00   | 7.60                    | .0026    | .0102            | .44       | .0030       | .0002     | .5110            | 2.6       | .1200 |
| 10491   | June 7              | V. slight.              | V. slight.     | 0.65   | 7.30                    | .0036    | .0120            | .49       | .0030       | .0001     | .4891            | 2.5       | .0230 |
| 10610   | July 6              | Slight, milky.          | V. slight.     | 0.55   | 8.00                    | .0036    | .0086            | .52       | .0000       | .0000     | .4161            | 3.1       | .0330 |
| 10759   | Aug. 9              | Slight, milky.          | V. slight.     | 0.40   | 7.30                    | .0032    | .0066            | .70       | .0000       | .0000     | .3318            | 2.2       | .0100 |
| 11001   | Sept. 11            | Distinct, milky.        | Slight, rusty. | 0.50   | 8.80                    | .0046    | .0058            | .66       | .0000       | .0001     | .1716            | 3.5       | .0450 |
| 11156   | Oct. 9              | Distinct, milky.        | Cons.          | 0.50   | 9.20                    | .0034    | .0034            | .68       | .0000       | .0000     | .1848            | 3.1       | .0800 |
| 11320   | Nov. 9              | Distinct, milky.        | Cons., white.  | 1.30   | 22.50                   | .0000    | .0134            | .56       | .0000       | .0002     | .3071            | 9.7       | .5400 |
| 11464   | Dec. 5              | Distinct, milky, rusty. | Heavy, rusty.  | 0.30   | 16.50                   | .0048    | .0066            | .59       | .0000       | .0001     | .1755            | 6.7       | .2100 |
| Av.     |                     |                         |                | 0.64   | 10.08                   | .0034    | .0087            | .56       | .0032       | .0001     | .3497            | 3.9       | .1251 |

*Averages of Analyses of Previous Years.*

|   |      |   |   |      |       |       |       |     |       |       |       |     |       |
|---|------|---|---|------|-------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1891 | - | - | 0.13 | 12.96 | .0016 | .0063 | .43 | .0094 | .0001 | -     | 5.1 | -     |
| - | 1892 | - | - | 0.44 | 9.25  | .0042 | .0073 | .54 | .0071 | .0001 | -     | 3.4 | -     |
| - | 1893 | - | - | 0.64 | 10.08 | .0034 | .0087 | .56 | .0032 | .0001 | .3497 | 3.9 | .1251 |

NOTE to analyses of 1893; Odor faintly mouldy or unpleasant, often none; in June and July disagreeable. — The samples were collected from a faucet at the pumping station.

## READING.

This water offers a good instance of the effect of a marshy soil on the character of the water percolating through it. The organic matter of the soil consumes the free dissolved oxygen in the water and reduces the insoluble iron salts to the condition of protoxide, so that iron passes into solution in the water. On exposure of the water to the air the iron is again oxidized, forming first a precipitate which gives the water a milky appearance and ultimately settles as a rusty sediment. Conditions in some respects similar to those at Reading are found in Provincetown, Bradford and Watertown, and were found in the test wells at Attleborough (see Twenty-third Annual Report, 1891).

The determinations of turbidity and color in waters of this kind do not have the same significance as in surface waters, but they are, nevertheless, of interest as showing a condition which the water may assume, and are therefore given in the table.

*Microscopical Examination of Water from the Filler-gallery of the Reading Water Works.*

[Number of organisms per cubic centimeter.]

|                           | 1893. |        |        |       |       |       |       |        |       |       |       |       |
|---------------------------|-------|--------|--------|-------|-------|-------|-------|--------|-------|-------|-------|-------|
|                           | Jan.  | Feb.   | Mar.   | Apr.  | May.  | June. | July. | Aug.   | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, .     | 12    | 9      | 8      | 12    | 11    | 9     | 8     | 10     | 12    | 10    | 11    | 9     |
| Number of sample, .       | 9869  | 9984   | 10082  | 10225 | 10377 | 10491 | 10610 | 10759  | 11001 | 11156 | 11320 | 11464 |
| PLANTS.                   |       |        |        |       |       |       |       |        |       |       |       |       |
| Fungi, . . . . *          | 4,364 | 0      | 728    | 2,120 | pr.   | 6     | 730   | 15,200 | 31    | 76    | 320   |       |
| Crenothrix, . . *         | 4,364 | 0      | 728    | 2,120 | 0     | 0     | 730   | 15,200 | 31    | 76    | 320   |       |
| Molds, . . . .            | 0     | 0      | 0      | 0     | 0     | pr.   | 6     | 0      | 0     | 0     | 0     | 0     |
| Miscellaneous, Zoöglæa, . | 0     | 0      | 17,160 | 0     | 0     | 0     | 0     | 3      | 400   | 80    | 4,000 | 1,360 |
| TOTAL, . . . . *          | 4,364 | 17,160 | 728    | 2,120 | pr.   | 6     | 733   | 15,600 | 111   | 4,076 | 1,680 |       |

\* Crenothrix too fine and too abundant to count.

WATER SUPPLY OF REVERE AND WINTHROP. — REVERE WATER COMPANY.

This company obtains part of its supply from wells in Revere and part from wells in Saugus. During the year 1893 there was a sudden and very decided increase in the quantity of chlorine present in the water of the wells located at Revere, as shown by the analyses on the following page, accompanied by a corresponding increase in residue on evaporation and in hardness. This deterioration in the char-

**REVERE.**

acter of the water is due to the presence of a small amount of sea water in the water of these wells, which are located only a comparatively short distance from salt water.

*Chemical Examination of Water from the Wells of the Revere Water Company, at Revere.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         |                     |             |           |        |                         |          |                  |           |             |           |                  |           |       |
| 1893.   |                     |             |           |        |                         |          |                  |           |             |           |                  |           |       |
| 10009   | Feb. 14             | None.       | None.     | 0.00   | 26.70                   | .0000    | .0032            | 4.20      | .0900       | .0025     | .0397            | 15.6      | .0000 |
| 10253   | Apr. 14             | None.       | None.     | 0.00   | 23.75                   | .0000    | .0006            | 3.49      | .0700       | .0025     | .0292            | 12.1      | .0040 |
| 10524   | June 15             | None.       | None.     | 0.00   | 29.50                   | .0000    | .0032            | 4.53      | .1500       | .0015     | .0000            | 13.0      | .0050 |
| 10848   | Aug. 16             | Slight.     | Slight.   | 0.02   | 31.80                   | .0012    | .0062            | 6.12      | .0900       | .0002     | .0780            | 11.7      | .0000 |
| 11205   | Oct. 15             | None.       | None.     | 0.00   | 75.60                   | .0000    | .0000            | 24.60     | .0900       | .0016     | .0202            | 31.2      | .0060 |
| 11288   | Nov. 2              | None.       | None.     | 0.00   | 71.30                   | .0000    | .0000            | 23.22     | .0450       | .0035     | .0680            | 36.6      | .0100 |
| 11495   | Dec. 5              | None.       | None.     | 0.00   | 93.40                   | .0000    | .0000            | 25.19     | .1000       | .0013     | .0720            | 40.5      | .0000 |
| Av...   | .....               | .....       | .....     | 0.00   | 50.29                   | .0002    | .0019            | 13.05     | .0907       | .0019     | .0439            | 23.0      | .0086 |

*Averages of Analyses of Previous Years.*

|   |       |   |   |     |       |       |       |       |       |       |       |      |       |
|---|-------|---|---|-----|-------|-------|-------|-------|-------|-------|-------|------|-------|
| - | 1887* | - | - | 0.0 | 22.17 | .0002 | .0016 | 3.37  | .1670 | -     | -     | -    | -     |
| - | 1888  | - | - | 0.0 | 22.69 | .0001 | .0022 | 3.49  | .1288 | .0022 | -     | -    | -     |
| - | 1889† | - | - | 0.0 | 22.72 | .0000 | .0016 | 3.28  | .1330 | .0027 | -     | -    | -     |
| - | 1890† | - | - | 0.0 | -     | .0008 | .0012 | 3.39  | .1750 | .0024 | -     | -    | -     |
| - | 1893  | - | - | 0.0 | 50.29 | .0002 | .0019 | 13.05 | .0907 | .0019 | .0439 | 23.0 | .0086 |

\* June to December.

† January to May.

‡ March.

NOTE to analyses of 1893: Odor, of No. 10848, unpleasant; of the remaining samples, none. — The samples were collected from a faucet at the pumping station at Revere and represent water from the wells at Revere only.

*Microscopical Examination of Water from the Wells of the Revere Water Company, at Revere.*

[Number of organisms per cubic centimeter.]

|                           | 1893. |       |       |       |       |       |       |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|
|                           | Feb.  | Apr.  | June. | Aug.  | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . | 15    | 15    | 16    | 18    | 19    | 4     | 15    |
| Number of sample, . . .   | 10009 | 10253 | 10524 | 10848 | 11205 | 11288 | 11495 |
| <b>PLANTS.</b>            |       |       |       |       |       |       |       |
| Diatomaceæ, . . .         | pr.   | 0     | 0     | 405   | 8     | 0     | 0     |
| Pinnularia, . . .         | 0     | 0     | 0     | 5     | 0     | 0     | 0     |
| Synedra, . . .            | 0     | 0     | 0     | 296   | 0     | 0     | 0     |
| Tabellaria, . . .         | pr.   | 0     | 0     | 104   | 6     | 0     | 0     |
| Fungi, Crenothrix, . . .  | 5     | 0     | 0     | 0     | 7     | 2     | 0     |

## REVERE.

*Microscopical Examination of Water from the Wells of the Revere Water Company, at Revere — Concluded.*

[Number of organisms per cubic centimeter.]

|                           | 1893. |      |       |      |      |      |      |
|---------------------------|-------|------|-------|------|------|------|------|
|                           | Feb.  | Apr. | June. | Aug. | Oct. | Nov. | Dec. |
| <b>ANIMALS.</b>           |       |      |       |      |      |      |      |
| Infusoria, . . . .        | 0     | 0    | 0     | 498  | 0    | pr.  | 0    |
| Monas, . . . .            | 0     | 0    | 0     | 40   | 0    | pr.  | 0    |
| Peridinium, . . . .       | 0     | 0    | 0     | 448  | 0    | 0    | 0    |
| Vermes, . . . .           | 0     | 0    | 0     | 5    | 0    | 0    | 0    |
| Anurea, . . . .           | 0     | 0    | 0     | 4    | 0    | 0    | 0    |
| Rotatorian ova, . . . .   | 0     | 0    | 0     | 1    | 0    | 0    | 0    |
| Miscellaneous, Zoëglæa, . | 14    | 0    | 0     | 0    | 4    | 8    | 0    |
| TOTAL, . . . .            | 19    | 0    | 0     | 898  | 17   | 10   | 0    |

*Chemical Examination of Water from Tubular Wells of the Revere Water Company, at Cliftondale, Saugus.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         |                     |             |            |        |                         |          |                  |           |             |           |                  |           |       |
| 1893.   |                     |             |            |        |                         |          |                  |           |             |           |                  |           |       |
| 10008   | Feb. 13             | None.       | V. slight. | 0.00   | 10.40                   | .0000    | .0020            | 1.66      | .0480       | .0100     | .0322            | 6.8       | .0000 |
| 10254   | Apr. 13             | None.       | None.      | 0.00   | 12.20                   | .0000    | .0012            | 1.12      | .1000       | .0125     | .0182            | 5.7       | .0040 |
| 10525   | June 15             | V. slight.  | Slight.    | 0.01   | 13.00                   | .0004    | .0022            | 1.74      | .1000       | .0090     | .0167            | 6.1       | .0000 |
| 10847   | Aug. 16             | Slight.     | Slight.    | 0.00   | 14.10                   | .0010    | .0004            | 1.13      | .0750       | .0032     | .0078            | 6.7       | .0100 |
| 11206   | Oct. 14             | None.       | V. slight. | 0.00   | 12.80                   | .0000    | .0000            | 1.18      | .1000       | .0065     | .0445            | 6.9       | .0080 |
| 11496   | Dec. 7              | None.       | None.      | 0.00   | 13.10                   | .0000    | .0000            | 1.11      | .1000       | .0060     | .0320            | 6.0       | .0000 |
| Av...   | .....               | .....       | .....      | 0.00   | 12.60                   | .0002    | .0010            | 1.32      | .0872       | .0079     | .0252            | 6.4       | .0037 |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |       |       |       |      |       |       |       |     |       |
|---|-------|---|---|------|-------|-------|-------|------|-------|-------|-------|-----|-------|
| - | 1891* | - | - | 0.00 | 11.50 | .0018 | .0014 | 0.88 | .0100 | .0000 | -     | 5.3 | -     |
| - | 1892  | - | - | 0.01 | 11.65 | .0000 | .0003 | 1.16 | .6123 | .0035 | -     | 6.0 | .0118 |
| - | 1893  | - | - | 0.00 | 12.60 | .0002 | .0010 | 1.32 | .0872 | .0079 | .0252 | 6.4 | .0037 |

\* September.

NOTE to analyses of 1893: Odor, none. In June a faintly unpleasant odor was developed on heating. — The samples were collected from a faucet at the pumping station at Cliftondale, Saugus.

*Microscopical Examination.*No. 10008. Fungi, *Crenothrix*, 4.No. 10525. Miscellaneous, *Zoëglæa*, 3.

No organisms were found in the remaining samples.



## ROCHESTER.

## ROCHESTER.

*Chemical Examination of Water from Snipatuit Pond, Rochester.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |            |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.     | Dissolved. | Suspended. |           |             |           |                  |           |
| 10661   | 1893.<br>July 12    | V. slight.  | V. slight. | 1.20   | 4.05                    | 2.35              | .0000    | .0236      | .0216      | .0020      | .48       | .0000       | .0000     | .0344            | 0.3       |

Iron, .0035. Odor, none. — The sample was collected from the pond about two feet beneath the surface, in connection with an investigation for an additional water supply for New Bedford.

*Microscopical Examination.*

Miscellaneous, *Zoöglæa*, 3.

## WATER SUPPLY OF ROCKLAND.

(See *Abington*.)

## WATER SUPPLY OF ROCKPORT.

The advice of the State Board of Health with reference to Cape Pond and Mill Pond Brook as sources of water supply for the town of Rockport may be found on page 45 of this volume.

*Chemical Examination of Water from Cape Pond, Rockport.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 9993    | 1893.<br>Feb. 8     | Slight.     | V. slight. | 0.08   | 14.60                   | 2.05              | .0004    | .0180       | .0154      | .0026      | 6.10      | .0030       | .0000     | .2044            | 2.2       |

Iron, .0050. Odor, none, becoming faintly vegetable on heating. — The sample was collected from the pond about three hundred feet from the shore, near the outlet.

*Microscopical Examination.*

Diatomacæ, *Diatoma*, 72; *Synedra*, 4. Infusoria, *Dinobryon cuses*, 1. Total, 77.

SALEM AND BEVERLY.

WATER SUPPLY OF SALEM AND BEVERLY.

The advice of the State Board of Health to the city of Salem, with reference to increasing the joint water supply of Salem and Beverly, by diverting the waters of Longham Meadow Brook and of the brook flowing from Beaver and Norwood's Ponds into Wenham Lake, may be found on page 47 of this volume. Analyses of samples of water collected from the proposed sources are given in the tables on pages 277 and 278.

Chemical Examination of Water from Wenham Lake, in Beverly and Wenham.  
[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                     |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1892.   |                     |                     |                   |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 9864    | Jan. 10             | Slight.             | Slight.           | 0.02   | 5.20                            | 1.00                 | .0000    | .0120       | .0104      | .0016           | .80       | .0150          | .0000     | .1680            | 2.8       |
| 10106   | Mar. 9              | V. slight.          | V. slight.        | 0.04   | 5.25                            | 1.60                 | .0050    | .0093       | .0084      | .0014           | .84       | .0090          | .0001     | .0900            | 2.7       |
| 10222   | Apr. 7              | Distinct,<br>green. | Slight.           | 0.03   | 5.05                            | 0.75                 | .0052    | .0158       | .0128      | .0030           | .74       | .0100          | .0003     | .1460            | 2.3       |
| 10358   | May 8               | Slight.             | Slight.           | 0.03   | 5.60                            | 1.20                 | .0016    | .0098       | .0068      | .0030           | .75       | .0120          | .0000     | .1423            | 2.2       |
| 10482   | June 6              | Slight.             | Slight.           | 0.08   | 5.55                            | 1.35                 | .0020    | .0136       | .0112      | .0024           | .79       | .0100          | .0000     | .2518            | 2.3       |
| 10635   | July 10             | Slight,<br>green.   | Slight.           | 0.05   | 5.40                            | 1.90                 | .0024    | .0116       | .0100      | .0016           | .75       | .0000          | .0000     | .1898            | 2.6       |
| 10803   | Aug. 15             | Distinct.           | Slight,<br>green. | 0.02   | 5.00                            | 1.45                 | .0000    | .0172       | .0102      | .0070           | .76       | .0000          | .0000     | .1833            | 2.6       |
| 10996   | Sept. 9             | Slight.             | Slight,<br>green. | 0.02   | 5.55                            | 1.35                 | .0022    | .0148       | .0104      | .0044           | .75       | .0000          | .0000     | .1326            | 2.6       |
| 11135   | Oct. 4              | Slight.             | Slight.           | 0.05   | 5.85                            | 1.00                 | .0024    | .0116       | .0102      | .0014           | .76       | .0000          | .0000     | .1540            | 2.7       |
| 11289   | Nov. 6              | Slight.             | Slight.           | 0.03   | 5.75                            | 1.00                 | .0096    | .0156       | .0114      | .0042           | .77       | .0030          | .0001     | .1950            | 2.9       |
| 11455   | Dec. 6              | Slight.             | Slight.           | 0.03   | 6.20                            | 1.25                 | .0060    | .0112       | .0078      | .0034           | .76       | .0020          | .0001     | .1131            | 2.7       |
| Av.     | .....               | .....               | .....             | 0.04   | 5.49                            | 1.26                 | .0033    | .0130       | .0100      | .0030           | .77       | .0055          | .0001     | .1605            | 2.6       |

Averages of Analyses of Previous Years.

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 0.05 | 4.73 | 0.82 | .0025 | .0135 | -     | -     | .72 | .0019 | -     | -     | -   |
| - | 1888  | - | - | 0.05 | 4.67 | 0.97 | .0020 | .0146 | -     | -     | .73 | .0058 | .0001 | -     | -   |
| - | 1889  | - | - | 0.06 | 4.23 | 1.05 | .0014 | .0173 | .0138 | .0035 | .72 | .0052 | .0002 | -     | -   |
| - | 1890  | - | - | 0.05 | 4.57 | 0.90 | .0016 | .0154 | .0125 | .0029 | .74 | .0104 | .0001 | -     | 2.5 |
| - | 1891  | - | - | 0.07 | 4.70 | 1.12 | .0006 | .0147 | .0113 | .0034 | .72 | .0125 | .0000 | -     | 1.9 |
| - | 1892  | - | - | 0.03 | 4.85 | 1.10 | .0016 | .0137 | .0103 | .0034 | .75 | .0077 | .0000 | -     | 2.2 |
| - | 1893  | - | - | 0.04 | 5.49 | 1.26 | .0033 | .0130 | .0100 | .0030 | .77 | .0055 | .0001 | .1606 | 2.6 |

\* June to December.

NOTE to analyses of 1893: Iron, .0052. Odor, vegetable and frequently unpleasant, becoming stronger on heating and sometimes mouldy. — The first two samples were collected from faucets at the pumping station; the remaining samples from the lake near the inlet pipe of the Salem Water Works.

## SALEM AND BEVERLY.

*Microscopical Examination of Water from Wenham Lake, in Beverly and Wenham.*

[Number of organisms per cubic centimeter.]

|                           | 1893. |       |       |       |       |       |       |       |       |       |       |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                           | Jan.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . | 11    | 10    | 8     | 9     | 7     | 13    | 16    | 12    | 5     | 8     | 7     |
| Number of sample, . . .   | 9864  | 10106 | 10222 | 10358 | 10482 | 10635 | 10803 | 10996 | 11135 | 11289 | 11455 |
| PLANTS.                   |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .         | 1,358 | 445   | 1,518 | 2,120 | 31    | 109   | 1,589 | 743   | 2,603 | 1,215 | 334   |
| Asterionella, . . .       | 1     | 1     | 64    | 1,700 | 0     | 30    | 0     | 88    | 2,356 | 800   | 84    |
| Cyclotella, . . .         | 120   | 30    | 56    | 168   | 30    | 40    | 1     | 1     | 10    | 0     | 200   |
| Fragilaria, . . .         | 0     | 5     | 0     | 2     | 0     | 20    | 228   | 15    | 0     | 14    | 0     |
| Melosira, . . .           | 0     | 7     | 63    | 188   | 0     | 6     | 0     | 38    | 176   | 200   | 17    |
| Stephanodiscus, . . .     | 1     | 0     | 0     | 36    | 0     | 0     | 0     | 0     | 0     | 200   | 24    |
| Synedra, . . .            | 0     | 2     | 0     | 86    | 1     | pr.   | 0     | 1     | 0     | pr.   | 3     |
| Tabellaria, . . .         | 1,236 | 400   | 1,330 | 0     | pr.   | 13    | 1,360 | 600   | 61    | 1     | 6     |
| Cyanophyceæ, . . .        | 0     | 0     | 0     | 0     | 4     | 0     | 124   | 92    | 5     | 5     | 0     |
| Anabæna, . . .            | 0     | 0     | 0     | 0     | 4     | 0     | 124   | 92    | 0     | 2     | 0     |
| Microcystis, . . .        | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 5     | 3     | 0     |
| Algæ, . . .               | 34    | 2     | 4     | pr.   | 5     | 6     | 7     | 86    | 516   | 17    | 112   |
| Chlorococcus, . . .       | 0     | 0     | 4     | 0     | 0     | 0     | 0     | 0     | 512   | 17    | 112   |
| Gleocystis, . . .         | 0     | 0     | 0     | 0     | 0     | 1     | 7     | 8     | 0     | 0     | 0     |
| Hyalotheca, . . .         | 5     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 0     | 0     |
| Protooccus, . . .         | 28    | 2     | 0     | 0     | 5     | 2     | 0     | 76    | 0     | 0     | 0     |
| Staurostrum, . . .        | 1     | 0     | 0     | pr.   | 0     | 3     | 0     | 2     | 0     | 0     | 0     |
| ANIMALS.                  |       |       |       |       |       |       |       |       |       |       |       |
| Rhizopoda, Diffugia, . .  | 1     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | pr.   | 0     |
| Infusoria, . . .          | 123   | 45    | 22    | 0     | 0     | 1     | 1     | 4     | 10    | 16    | 7     |
| Dinobryon, . . .          | 5     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 3     | 5     |
| Dinobryon cases, . .      | 112   | 25    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 11    | 0     |
| Monas, . . .              | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 1     | 0     | 0     |
| Peridinium, . . .         | 0     | 0     | 16    | 0     | 0     | 0     | 0     | 2     | 6     | pr.   | 0     |
| Trachelomonas, . .        | 6     | 17    | 6     | 0     | 0     | 0     | 1     | 2     | 3     | 2     | 2     |
| Vermes, . . .             | 0     | 0     | 0     | 0     | 0     | pr.   | 1     | 10    | 0     | pr.   | 0     |
| Anurea, . . .             | 0     | 0     | 0     | 0     | 0     | pr.   | 1     | 7     | 0     | pr.   | 0     |
| Polyarthra, . . .         | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | pr.   | 0     |
| Rotatorian ova, . .       | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     |
| Miscellaneous, Zoöglæa, . | 0     | 38    | 0     | 16    | 0     | 38    | 84    | 56    | 128   | 28    | 0     |
| TOTAL, . . .              | 1,516 | 530   | 1,545 | 2,136 | 40    | 154   | 1,806 | 991   | 3,262 | 1,281 | 453   |

## SALEM AND BEVERLY.

*Table showing Heights of Water in Wenham Lake at Times when Samples of Water were collected for Analysis.*

[NOTE. — High-water mark is 30.17 feet.]

| DATE.              |  |  | Height of Water. | DATE.              |  |  | Height of Water. |
|--------------------|--|--|------------------|--------------------|--|--|------------------|
| 1893.              |  |  | Feet.            | 1893.              |  |  | Feet.            |
| Jan. 10, . . . . . |  |  | 20.92            | Aug. 15, . . . . . |  |  | 23.35            |
| Mar. 9, . . . . .  |  |  | 20.96            | Sept. 9, . . . . . |  |  | 22.77            |
| Apr. 7, . . . . .  |  |  | 22.69            | Oct. 4, . . . . .  |  |  | 22.00            |
| May 8, . . . . .   |  |  | 23.87            | Nov. 6, . . . . .  |  |  | 21.58            |
| June 6, . . . . .  |  |  | 24.67            | Dec. 6, . . . . .  |  |  | 21.33            |
| July 10, . . . . . |  |  | 24.31            |                    |  |  |                  |

*Chemical Examination of Water from Beaver Pond, Norwood's Pond, and Longham Meadow Brook, in Beverly.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |                    |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|--------------------|--------------------|--------|-------------------------|-------------------|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.         | Sediment.          | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.   | Nitritea. |                  |           |
|         |                     |                    |                    |        |                         |                   |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |           |
| 10072   | 1893.<br>Mar. 1     | Slight.            | Cons.              | 1.20   | 5.10                    | 2.00              | .0102    | .0218       | .0180      | .0038           | .80       | .0030       | .0002     | .5983            | 1.3       |
| 10073   | Mar. 1              | Slight.            | Slight.            | 1.40   | 5.50                    | 2.40              | .0098    | .0224       | .0196      | .0028           | .70       | .0030       | .0002     | 1.0764           | 1.3       |
| 10074   | Mar. 1              | Slight.            | Cons.,<br>brown.   | 1.50   | 7.05                    | 2.65              | .0036    | .0328       | .0300      | .0028           | 1.00      | .0150       | .0002     | 1.1304           | 2.2       |
| 10132   | Mar. 15             | Slight.            | Slight.            | 0.70   | 4.25                    | 1.70              | .0086    | .0162       | .0140      | .0022           | .62       | .0070       | .0000     | .6201            | 1.3       |
| 10133   | Mar. 15             | Slight,<br>clayey. | Slight,<br>earthy. | 0.50   | 3.25                    | 1.85              | .0056    | .0210       | .0164      | .0046           | .43       | .0000       | .0000     | .6238            | 0.9       |

Iron in the first sample, .0650; in the next two, .0500 each; in the fourth, .0600; in the last, .0150. Odor of the first three samples distinctly vegetable and of the first one also disagreeable. Of the last two samples, No. 10132 had a very faintly vegetable odor and No. 10133 none. — Nos. 10072 and 10132 were collected from the brook flowing from Norwood's Pond; No. 10073, from the brook flowing from Beaver Pond; Nos. 10074 and 10133, from Longham Meadow Brook just above the point where it is joined by the brook flowing from Norwood's Pond.

## SALEM AND BEVERLY.

*Microscopical Examination of Water from Beaver Pond, Norwood's Pond, and Longham Meadow Brook, in Beverly.*

[Number of organisms per cubic centimeter.]

|                                 | 1892.  |        |        |        |        |
|---------------------------------|--------|--------|--------|--------|--------|
|                                 | March. | March. | March. | March. | March. |
| Day of examination, . . . .     | 3      | 3      | 3      | 17     | 17     |
| Number of sample, . . . .       | 10072  | 10073  | 10074  | 10132  | 10133  |
| <b>PLANTS.</b>                  |        |        |        |        |        |
| Diatomaceæ, . . . . .           | 0      | 2      | 5      | 3      | 17     |
| Fragilaria, . . . . .           | 0      | 0      | 0      | 2      | 4      |
| Navicula, . . . . .             | 0      | 0      | 1      | pr.    | 5      |
| Synedra, . . . . .              | 0      | pr.    | 3      | 1      | 6      |
| Tabellaria, . . . . .           | 0      | 2      | 1      | 0      | 2      |
| Cyanophyceæ, Nostoc spores, .   | 0      | 0      | 0      | 1      | 0      |
| Algæ, Zoöspores, . . . . .      | 2      | 0      | 0      | 2      | 0      |
| Fungi, . . . . .                | 0      | 0      | 18     | 2      | 0      |
| Beggiatoa, . . . . .            | 0      | 0      | 0      | 2      | 0      |
| Cladotrix, . . . . .            | 0      | 0      | 18     | 0      | 0      |
| <b>ANIMALS.</b>                 |        |        |        |        |        |
| Infusoria, . . . . .            | 3      | 8      | 0      | 9      | 2      |
| Dinobryon, . . . . .            | 0      | 1      | 0      | 4      | 2      |
| Peridinium, . . . . .           | 3      | 7      | 0      | 5      | 0      |
| Miscellaneous, Zoöglæa, . . . . | 2,000  | 70     | 2      | 180    | 58     |
| TOTAL, . . . . .                | 2,005  | 80     | 25     | 197    | 77     |

## WATER SUPPLY OF SAUGUS.

(See *Lynn*.)

## SCITUATE.

The advice of the State Board of Health with reference to taking a water supply for the village of Scituate Harbor in the town of Scituate, from the ground in the vicinity of Satuit Brook, may be found on page 50 of this volume. An analysis of a sample of water from the flowing test well, referred to in the communication of the Board, is given below.

## SCITUATE.

*Chemical Examination of Water from a Tubular Test Well in Scituate.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 10017   | 1893.<br>Feb. 14    | None.       | None.     | 0.02   | 8.35                    | .0006    | .0010       | 1.74      | .0800       | .0000     | .0472            | 3.1       | .0000 |

Odor none. — The sample was collected from a flowing test well in a meadow near Willow Street about three hundred feet east of the railroad.

*Microscopical Examination.*

No organisms.

## WATER SUPPLY OF SHARON. — SHARON WATER COMPANY.

The reply of the State Board of Health to an application of the Board of Health of Sharon for advice with reference to the possible pollution of the water supply of the town under existing conditions, and as to the best practicable method of assuring its purity in the future, may be found on page 51 of this report.

*Chemical Examination of Water from the Well of the Sharon Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 10941   | 1893.<br>Aug. 31    | None.       | None.     | 0.0    | 10.70                   | .0000    | .0000       | .91       | .3750       | .0000     | .0158            | 2.8       | .0100 |

Odor, none. — The sample was collected from a faucet at the pumping station.

*Microscopical Examination.*

No organisms.

## WATER SUPPLY OF SOMERVILLE.

(See *Boston, Mystic Works.*)

## WATER SUPPLY OF SOUTHBRIDGE. — SOUTHBRIDGE WATER SUPPLY COMPANY.

The advice of the State Board of Health to the Southbridge Water Supply Company relative to increasing its supply by the

**SOUTHBRIDGE.**

construction of an additional storage reservoir about one mile south of the present upper reservoir, and as to improving the existing supply; also, at a subsequent date, with reference to increasing its supply by taking water from a proposed storage reservoir on Hatchet Brook, may be found on pages 51-53 of this volume. Analyses of samples of water collected from the present sources of supply and from Hatchet Brook and its tributaries are given in the following tables.

*Chemical Examination of Water from the Lower Reservoir of the Southbridge Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 11032   | 1893.<br>Sept. 15   | Decided.    | Cons.     | 0.15   | 3.75                            | 1.65                 | .0052    | .0554       | .0176      | .0378           | .22       | .0030          | .0002     | .3042            | 1.6       |

Iron, .0160. Odor, none, becoming distinctly vegetable and grassy on heating. — The sample was collected from the lower reservoir at a time when it was nearly empty.

*Microscopical Examination.*

Diatomaceæ, *Cyclotella*, 168; *Cymbella*, 1; *Diatoma*, 260; *Epithemia*, 1; *Gomphonema*, 3; *Navicula*, 2; *Pinnularia*, 4; *Surtirella*, 2; *Synedra*, 160; *Tabellaria*, 92. Algæ, *Arthrodesmus*, 1; *Pediastrum*, 7; *Scenedesmus*, 5; *Stauroneis*, 4. Infusoria, *Euglena*, 112; *Monas*, 2; *Peridinium*, 48. Vermes, *Anurea*, 1; *Polyarthra*, 2. Miscellaneous, *Zoëglæa*, 60. Total, 935.

*Chemical Examination of Water from Glover Spring, Southbridge.*

[Parts per 100,000.]

| Number. | Date of<br>Collection. | APPEARANCE. |            |        | Residue on<br>Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN<br>AS |           | Oxygen<br>Consumed. | Hardness. | Iron. |
|---------|------------------------|-------------|------------|--------|----------------------------|----------|------------------|-----------|----------------|-----------|---------------------|-----------|-------|
|         |                        | Turbidity.  | Sediment.  | Color. |                            | Free.    | Albu-<br>minoid. |           | Nitrates.      | Nitrites. |                     |           |       |
|         |                        |             |            |        |                            |          |                  |           |                |           |                     |           |       |
| 11033   | 1893.<br>Sept. 14      | None.       | None.      | 0.00   | 10.75                      | .0000    | .0002            | .80       | .4000          | .0001     | .1950               | 3.8       | .0075 |
| 11258   | Oct. 26                | V. slight.  | V. slight. | 0.08   | 12.90                      | .0000    | .0030            | 1.00      | .4350          | .0000     | .0190               | 3.9       | .0020 |

Odor of the first sample, none; of the second sample, distinctly unpleasant, disappearing on heating. — The first sample was collected from a faucet in Southbridge supplied from the spring; the last, directly from the spring. The spring is located a short distance below the lower reservoir of the Southbridge Water Company, in the valley of the brook upon which the reservoirs of this company are built, and is used as a source of supply for several families.

*Microscopical Examination.*

No. 11033. Algæ, *Raphidium*, 2. Miscellaneous, *Zoëglæa*, 1. Total, 3.  
No. 11258. Miscellaneous, *Zoëglæa*, 1.

## SOUTHBRIDGE.

*Chemical Examination of Water from Hatchet Brook and one of its Tributaries in Southbridge.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |       | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           |             |       |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |       |                  |           |
| 11031   | 1893.<br>Sept. 14   | V. slight.  | V. slight. | 0.10   | 4.65                    | 0.80              | .0000    | .0042       | .0030      | .0012      | .21       | .0000       | .0000 | .1404            | 1.7       |
| 11256   | Oct. 26             | V. slight.  | Slight.    | 1.50   | 8.05                    | 3.60              | .0000    | .0242       | .0214      | .0028      | .38       | .0000       | .0000 | 1.2616           | 1.9       |
| 11358   | Nov. 20             | Slight.     | Slight.    | 0.30   | 4.25                    | 1.25              | .0000    | .0118       | .0106      | .0012      | .20       | .0050       | .0000 | .5208            | 1.4       |
| 11359   | Nov. 20             | None.       | V. slight. | 0.50   | 4.65                    | 1.40              | .0006    | .0128       | .0110      | .0018      | .20       | .0006       | .0000 | .6762            | 1.4       |
| Av.     | .....               | .....       | .....      | 0.60   | 5.40                    | 1.76              | .0002    | .0133       | .0115      | .0018      | .25       | .0015       | .0000 | .6498            | 1.6       |

Iron in the first sample, .0060; in the second, .0070; in the third, .0050; in the last, .0020. Odor of the first sample, none; of the remaining samples, very faintly vegetable, becoming stronger on heating. — The first sample was collected from Hatchet Brook at a road crossing about three-fourths of a mile from its mouth; the second and last samples, from the brook at site of proposed dam of the Southbridge Water Company, about half a mile above the point where the first sample was collected; the third sample, from a small tributary which enters Hatchet Brook from the west, about half a mile above the site of the proposed dam.

*Microscopical Examination of Water from Hatchet Brook in Southbridge.*

[Number of organisms per cubic centimeter.]

|                                   | 1893.      |          |           |           |
|-----------------------------------|------------|----------|-----------|-----------|
|                                   | September. | October. | November. | November. |
| Day of examination, . . . . .     | 16         | 28       | 22        | 22        |
| Number of sample, . . . . .       | 11031      | 11256    | 11358     | 11359     |
| PLANTS.                           |            |          |           |           |
| Diatomaceæ, . . . . .             | 3          | 1        | 4         | 3         |
| Meridion, . . . . .               | 0          | 0        | 2         | 1         |
| Synedra, . . . . .                | 0          | 1        | 2         | 2         |
| Tabellaria, . . . . .             | 3          | 0        | pr.       | 0         |
| Fungi, Crenothrix, . . . . .      | 230        | 27       | 22        | 7         |
| ANIMALS.                          |            |          |           |           |
| Vermes, Anurea, . . . . .         | 0          | 1        | 0         | 0         |
| Miscellaneous, Zoöglæa, . . . . . | 0          | 3        | 14        | 1         |
| TOTAL, . . . . .                  | 233        | 32       | 40        | 11        |



## SOUTHBRIDGE.

*Chemical Examination of Water from Hatchet Pond in Woodstock, Conn., just South of the Boundary between Massachusetts and Connecticut.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |           |
| 11257   | 1893.<br>Oct. 26    | Slight.     | Slight.   | 0.15   | 2.10                    | 0.65              | .0000    | .0142       | .0102      | .0040           | .16       | .0000       | .0000     | .3192            | 0.5       |
| 11360   | Nov. 20             | Slight.     | Slight.   | 0.02   | 2.10                    | 0.70              | .0022    | .0148       | .0126      | .0022           | .15       | .0050       | .0000     | .2520            | 0.8       |

Iron, .0025. Odor of the first sample, faintly vegetable, becoming distinctly vegetable and unpleasant on heating; of the second sample, very faintly vegetable, disappearing on heating. — The samples were collected from the pond which is located at the head of Hatchet Brook.

*Microscopical Examination.*

No. 11257. Diatomaceæ, *Synedra*, 1. Cyanophycæ, *Anabæna*, 4; *Celosphaerium*, 1; *Merismopedia*, 480. Algæ, *Chlorococcus*, 10. Fungi, *Oreothrix*, 39. Miscellaneous, *Zoöglæa*, 4. Total, 438.

No. 11360. Diatomaceæ, *Navicula*, 1. Cyanophycæ, *Merismopedia*, 19. Algæ, *Protococcus*, 2; *Raphidium*, 2. Total, 24.

## WATER SUPPLY OF SOUTH HADLEY FALLS FIRE DISTRICT, SOUTH HADLEY.

*Chemical Examination of Water from a Faucet in South Hadley, supplied from Bullery Brook Reservoir.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 11558   | 1893.<br>Dec. 27    | Slight.     | Slight.   | 0.10   | 3.20                    | 0.90              | .0008    | .0030       | .0014      | .0016      | .15       | .0250       | .0000     | .1309            | 0.8       |

Iron, .0125. Odor, none, becoming faintly vegetable on heating.

*Microscopical Examination.*

Miscellaneous, *Zoöglæa*, 14.

SPENCER.

## WATER SUPPLY OF SPENCER.

*Chemical Examination of Water from Shaw Pond, Leicester.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. |           |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                |           | Nitrates.      | Nitrites. | Oxygen Consumed. | Hardness. |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended |           |                |           |                  |           |
| 1893.   |                     |             |            |        |                                 |                      |          |             |            |                |           |                |           |                  |           |
| 9994    | Feb. 8              | V. slight.  | V. slight. | 0.05   | 2.85                            | 0.85                 | .0048    | .0202       | .0148      | .0054          | .22       | .0070          | .0001     | .1131            | 1.1       |
| 10174   | Mar. 27             | Slight.     | Slight.    | 0.02   | 1.55                            | 0.45                 | .0034    | .0086       | .0060      | .0026          | .12       | .0050          | .0001     | .0912            | 0.5       |
| 10315   | Apr. 26             | None.       | None.      | 0.02   | 1.90                            | 0.40                 | .0000    | .0060       | .0038      | .0022          | .13       | .0070          | .0000     | .1058            | 0.3       |
| 10387   | May 14              | None.       | V. slight. | 0.03   | 2.05                            | 0.35                 | .0004    | .0084       | .0066      | .0018          | .11       | .0030          | .0000     | .0803            | 0.9       |
| 10789   | Aug. 13             | V. slight.  | V. slight. | 0.03   | 3.00                            | 1.10                 | .0004    | .0136       | .0102      | .0034          | .14       | .0000          | .0000     | .1382            | 1.0       |
| 10961   | Sept. 4             | Slight.     | Slight.    | 0.05   | 2.25                            | 0.60                 | .0018    | .0192       | .0166      | .0026          | .14       | .0030          | .0000     | .1480            | 0.7       |
| Av.     | .....               | .....       | .....      | 0.03   | 2.27                            | 0.63                 | .0018    | .0127       | .0097      | .0030          | .14       | .0042          | .0000     | .1128            | 0.8       |

Iron, .0033. Odor of the first four samples, faintly vegetable; of the last two samples, none. — The first two samples and the last were collected from the pond; the remaining samples, from a faucet in the town.

*Microscopical Examination of Water from Shaw Pond, Leicester.*

[Number of organisms per cubic centimeter.]

|                               | 1893. |        |        |       |       |       |
|-------------------------------|-------|--------|--------|-------|-------|-------|
|                               | Feb.  | March. | April. | May.  | Aug.  | Sept. |
| Day of examination, . . . . . | 11    | 29     | 27     | 16    | 15    | 6     |
| Number of sample, . . . . .   | 9994  | 10174  | 10315  | 10387 | 10789 | 10961 |
| <b>PLANTS.</b>                |       |        |        |       |       |       |
| Diatomaceæ, . . . . .         | 3     | 4      | 5      | 1     | 14    | 28    |
| Asterionella, . . . . .       | 0     | 0      | 4      | 0     | 0     | 14    |
| Melosira, . . . . .           | 1     | 0      | 0      | 0     | 14    | 13    |
| Synedra, . . . . .            | 2     | 4      | 1      | 1     | 0     | 1     |
| Algae, . . . . .              | 0     | 0      | 0      | 0     | 106   | 60    |
| Botryococcus, . . . . .       | 0     | 0      | 0      | 0     | 0     | 60    |
| Protococcus, . . . . .        | 0     | 0      | 0      | 0     | 106   | 0     |

## SPENCER.

*Microscopical Examination of Water from Shaw Pond, Leicester — Concluded.*

[Number of organisms per cubic centimeter.]

|                                   | 1893. |        |        |      |      |       |
|-----------------------------------|-------|--------|--------|------|------|-------|
|                                   | Feb.  | March. | April. | May. | Aug. | Sept. |
| <b>ANIMALS.</b>                   |       |        |        |      |      |       |
| Infusoria, . . . . .              | 28    | 9      | 11     | 0    | 0    | 0     |
| Dinobryon, . . . . .              | 0     | 3      | 0      | 0    | 0    | 0     |
| Dinobryon cases, . . . . .        | 26    | 5      | 11     | 0    | 0    | 0     |
| Trachelomonas, . . . . .          | pr.   | 1      | 0      | 0    | 0    | 0     |
| Miscellaneous, Zoöglæa, . . . . . | 0     | 48     | 0      | 5    | 18   | 60    |
| TOTAL, . . . . .                  | 29    | 61     | 16     | 6    | 138  | 148   |

## WATER SUPPLY OF SPRINGFIELD.

During the summer and autumn of 1893 the amount of water furnished by the Ludlow Receiving Basin and its tributary canals was insufficient for the supply of the city, and, to make up the deficiency, water was taken from the old Ludlow Reservoir and from Chapin Pond, which is situated near the main pipe leading to the city. It happened somewhat inopportunistly that, with a view to improving the character of the water, the old Ludlow Reservoir had been drawn off during the latter part of 1892 and was empty on, and for several months after, the first of January, 1893. While the reservoir was empty, a new waste-gate was put in at the Cherry Valley dam in order to make it possible to waste water from the bottom of this reservoir in the future, when desirable, and at the completion of this work on May 9, 1893, the filling of the reservoir was begun again; but the amount of water collected during the remainder of the year was so small that the water in the reservoir did not rise high enough to flow through the pipe beneath the cut-off dam into the Ludlow Receiving Basin, and in order to use the water which had accumulated, for the supply of the city, it was necessary to pump it into the basin. Pumping was begun on Aug. 22, 1893, and continued until October 24, the total quantity pumped being 63,000,000 gallons.

Chapin Pond is located in a sandy plain in the southwesterly part of Ludlow, and is said to have an area of about thirty acres

## SPRINGFIELD.

and a considerable depth. It has no visible inlet or outlet and is supplied with water which percolates into it from the sandy territory by which it is surrounded. The lowering of the water in the pond by pumping doubtless makes available a considerable quantity of water stored in the ground about it. Between Aug. 7 and Oct. 28, 1893, a total of 164,000,000 gallons of water were pumped from this source. An analysis of the water of Chapin Pond is given with the analyses of samples of water from the other sources of supply in the tables below.

*Chemical Examination of Water from the Receiving Basin of the Springfield Water Works, at Ludlow.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |                    |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|--------------------|--------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.         | Sediment.          | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                    |                    |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1893.   |                     |                    |                    |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 9856    | Jan. 9              | Slight.            | V. slight.         | 0.50   | 4.35                            | 1.35                 | .0000    | .0194       | .0131      | .0060           | .18       | .0070          | .0000     | .5360            | 1.6       |
| 9979    | Feb. 7              | Slight.            | Slight,<br>white.  | 0.50   | 4.10                            | 1.35                 | .0032    | .0182       | .0152      | .0030           | .17       | .0030          | .0001     | .5037            | 1.7       |
| 10091   | Mar. 7              | V. slight.         | V. slight.         | 0.40   | 3.85                            | 1.10                 | .0042    | .0772       | .0052      | .0020           | .16       | .0090          | .0000     | .3348            | 1.4       |
| 10216   | April 5             | Slight.            | Slight.            | 0.40   | 2.25                            | 0.70                 | .0000    | .0102       | .0084      | .0018           | .09       | .0030          | .0001     | .3942            | 0.2       |
| 10370   | May 8               | Slight.            | Cons.,<br>green.   | 0.45   | 2.55                            | 0.65                 | .0000    | .0084       | .0072      | .0012           | .07       | .0000          | .0000     | .5584            | 0.5       |
| 10489   | June 6              | Distinct.          | Cons.,<br>brown.   | 0.50   | 3.00                            | 1.25                 | .0014    | .0168       | .0132      | .0036           | .18       | .0030          | .0001     | .4526            | 0.8       |
| 10605   | July 5              | Distinct,<br>green | Cons.,<br>brown.   | 0.40   | 3.55                            | 1.10                 | .0002    | .0194       | .0148      | .0046           | .10       | .0000          | .0001     | .3942            | 0.9       |
| 10835   | Aug. 16             | Distinct.          | Slight.            | 0.60   | 4.40                            | 2.20                 | .0008    | .0244       | .0208      | .0036           | .14       | .0000          | .0000     | .5772            | 1.0       |
| 10974   | Sept. 7             | Decided,<br>green. | Cons.,<br>yellow.  | 0.40   | 4.25                            | 2.00                 | .0000    | .0550       | .0232      | .0318           | .14       | .0000          | .0000     | .5640            | 1.8       |
| 11140   | Oct. 4              | Slight.            | Cons.,<br>green.   | 0.28   | 3.95                            | 1.80                 | .0004    | .0264       | .0190      | .0074           | .17       | .0000          | .0000     | .3784            | 1.3       |
| 11298   | Nov. 7              | V. slight.         | Slight.            | 0.80   | 4.70                            | 1.70                 | .0008    | .0204       | .0174      | .0030           | .26       | .0030          | .0002     | .7500            | 1.6       |
| 11444   | Dec. 5              | V. slight.         | Slight,<br>earthy. | 0.70   | 4.20                            | 1.45                 | .0009    | .0188       | .0168      | .0020           | .16       | .0030          | .0001     | .7137            | 1.1       |
| Av..    | .....               | .....              | .....              | 0.49   | 3.76                            | 1.39                 | .0009    | .0204       | .0146      | .0058           | .15       | .0026          | .0001     | .5132            | 1.2       |

Iron, .0102. Odor, generally distinctly vegetable, frequently grassy, sometimes none. In September the odor was strongly vegetable and mouldy. — The samples were collected from the basin in the vicinity of the gate-house. When the September and October samples were collected water was being pumped into this basin from Ludlow Reservoir.

## SPRINGFIELD.

*Microscopical Examination of Water from the Receiving Basin of the Springfield Water Works, at Ludlow.*

[Number of organisms per cubic centimeter.]

|                                  | 1892.     |            |            |            |            |            |            |            |            |            |            |           |
|----------------------------------|-----------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-----------|
|                                  | Jan.      | Feb.       | Mar.       | Apr.       | May.       | June.      | July.      | Aug.       | Sept.      | Oct.       | Nov.       | Dec.      |
| Day of examination, .            | 11        | 9          | 8          | 8          | 10         | 9          | 7          | 17         | 8          | 5          | 10         | 7         |
| Number of sample, .              | 9856      | 9979       | 10091      | 10216      | 10370      | 10489      | 10605      | 10835      | 10974      | 11140      | 11298      | 11444     |
| <b>PLANTS.</b>                   |           |            |            |            |            |            |            |            |            |            |            |           |
| <b>Diatomaceæ, . .</b>           | <b>6</b>  | <b>7</b>   | <b>4</b>   | <b>13</b>  | <b>903</b> | <b>49</b>  | <b>350</b> | <b>47</b>  | <b>53</b>  | <b>180</b> | <b>28</b>  | <b>24</b> |
| Asterionella, . .                | 0         | 0          | 0          | 3          | 570        | 1          | 0          | 0          | 0          | 0          | 5          | 0         |
| Cyclotella, . .                  | 2         | pr.        | 0          | 0          | 1          | 1          | 88         | 4          | 32         | 0          | 1          | 0         |
| Diatoma, . .                     | 0         | 1          | pr.        | 0          | 0          | 0          | 0          | 2          | 0          | 0          | 0          | 4         |
| Fragilaria, . .                  | 0         | 0          | 2          | 0          | 0          | 2          | 15         | 8          | 0          | 1          | 0          | 0         |
| Melosira, . .                    | 0         | 1          | 1          | 1          | 27         | 11         | 240        | 26         | 29         | 64         | 16         | 0         |
| Meridion, . .                    | 0         | 2          | pr.        | 2          | pr.        | 1          | 0          | 0          | 0          | 1          | 0          | 3         |
| Navicula, . .                    | 3         | pr.        | 1          | 1          | pr.        | 7          | 0          | 1          | 0          | 2          | 1          | 3         |
| Pinnularia, . .                  | 0         | 0          | 0          | 0          | 1          | 1          | 0          | 2          | 0          | 0          | 0          | 1         |
| Synedra, . .                     | 1         | 3          | pr.        | 5          | 3          | 24         | 1          | 3          | 1          | 112        | 5          | 10        |
| Tabellaria, . .                  | 0         | pr.        | 0          | 1          | 1          | 1          | 6          | 1          | 0          | 0          | 0          | 3         |
| <b>Cyanophyceæ, . .</b>          | <b>0</b>  | <b>0</b>   | <b>0</b>   | <b>pr.</b> | <b>0</b>   | <b>1</b>   | <b>64</b>  | <b>13</b>  | <b>280</b> | <b>128</b> | <b>4</b>   | <b>0</b>  |
| Anabaena, . .                    | 0         | 0          | 0          | pr.        | 0          | 0          | 64         | 2          | 200        | 44         | 0          | 0         |
| Anabaena spores, . .             | 0         | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 80         | 0          | 0          | 0         |
| Chroococcus, . .                 | 0         | 0          | 0          | 0          | 0          | 1          | 0          | 11         | 0          | 0          | 0          | 0         |
| Merismopedia, . .                | 0         | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 84         | 4          | 0         |
| <b>Algæ, . . . .</b>             | <b>0</b>  | <b>16</b>  | <b>pr.</b> | <b>5</b>   | <b>5</b>   | <b>2</b>   | <b>10</b>  | <b>31</b>  | <b>0</b>   | <b>317</b> | <b>18</b>  | <b>0</b>  |
| Chlorococcus, . .                | 0         | 0          | 0          | pr.        | 0          | 0          | 0          | 15         | 0          | 244        | 0          | 0         |
| Closterium, . .                  | 0         | 16         | pr.        | 5          | 2          | 0          | 0          | 0          | 0          | 0          | 0          | 0         |
| Nephrocyltum, . .                | 0         | 0          | 0          | 0          | 0          | 0          | 0          | 8          | 0          | 0          | 0          | 0         |
| Protococcus, . .                 | 0         | 0          | pr.        | 0          | 2          | 0          | 4          | 8          | 0          | 0          | 12         | 0         |
| Raphidium, . .                   | 0         | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 5          | 5          | 0         |
| Scenedesmus, . .                 | 0         | 0          | 0          | 0          | 0          | 2          | 1          | 0          | 0          | 68         | 1          | 0         |
| Zoöspores, . .                   | 0         | 0          | 0          | 0          | 1          | 0          | 5          | 0          | 0          | 0          | 0          | 0         |
| <b>Fungi, Crenothrix, .</b>      | <b>9</b>  | <b>0</b>   | <b>0</b>   | <b>pr.</b> | <b>0</b>   | <b>0</b>   | <b>0</b>   | <b>0</b>   | <b>0</b>   | <b>9</b>   | <b>7</b>   | <b>0</b>  |
| <b>ANIMALS.</b>                  |           |            |            |            |            |            |            |            |            |            |            |           |
| <b>Infusoria, . . .</b>          | <b>22</b> | <b>39</b>  | <b>3</b>   | <b>1</b>   | <b>2</b>   | <b>125</b> | <b>1</b>   | <b>42</b>  | <b>0</b>   | <b>4</b>   | <b>22</b>  | <b>1</b>  |
| Dinobryon, . .                   | 8         | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 0         |
| Dinobryon cases, . .             | 0         | 0          | 0          | 0          | 0          | 124        | 0          | 0          | 0          | 0          | 20         | 0         |
| Monas, . .                       | 0         | 1          | 0          | 0          | 1          | pr.        | 0          | 1          | 0          | 1          | 2          | 1         |
| Peridinium, . .                  | 14        | 38         | 3          | 1          | 1          | 0          | 1          | 40         | 0          | 2          | 0          | 0         |
| Trachelomonas, . .               | 0         | 0          | 0          | pr.        | 0          | 1          | 0          | 1          | 0          | 1          | 0          | 0         |
| <b>Miscellaneous, Zoöglæa, .</b> | <b>32</b> | <b>74</b>  | <b>2</b>   | <b>0</b>   | <b>24</b>  | <b>100</b> | <b>36</b>  | <b>68</b>  | <b>36</b>  | <b>160</b> | <b>40</b>  | <b>72</b> |
| <b>TOTAL, . . .</b>              | <b>69</b> | <b>136</b> | <b>9</b>   | <b>19</b>  | <b>934</b> | <b>277</b> | <b>461</b> | <b>201</b> | <b>369</b> | <b>798</b> | <b>119</b> | <b>97</b> |

## SPRINGFIELD.

*Chemical Examination of Water from Ludlow Reservoir.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                                  |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|----------------------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment.                        | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                     |                                  |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1893.   |                     |                     |                                  |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 10398   | May 15              | Decided.            | Heavy,<br>earthy &<br>floccul't. | 0.85   | 3.00                            | 1.25                 | .0032    | .0194       | .0148      | .0046           | .08       | .0030          | .0002     | .5256            | 0.8       |
| 10488   | June 6              | Distinct,<br>white. | Cons.,<br>white.                 | 0.45   | 3.30                            | 1.05                 | .0044    | .0230       | .0172      | .0058           | .18       | .0030          | .0001     | .5402            | 1.3       |
| 10604   | July 5              | Decided,<br>green.  | Heavy,<br>green.                 | 0.80   | 4.85                            | 2.25                 | .0000    | .0526       | .0348      | .0178           | .11       | .0030          | .0000     | .7008            | 1.1       |
| 10834   | Aug. 16             | Decided,<br>green.  | Slight,<br>yellow.               | 0.45   | 6.55                            | 3.95                 | .0002    | .0522       | .0300      | .0222           | .13       | .0030          | .0000     | .7176            | 1.3       |
| 10975   | Sept. 7             | Decided,<br>green.  | Cons.,<br>yellow.                | 0.50   | 4.90                            | 3.00                 | .0004    | .0532       | .0422      | .0110           | .13       | .0030          | .0001     | .7320            | 1.6       |
| 11141   | Oct. 4              | Slight.             | Cons.,<br>green.                 | 0.30   | 3.50                            | 1.75                 | .0000    | .0384       | .0260      | .0124           | .12       | .0000          | .0000     | .4928            | 1.1       |
| 11290   | Nov. 7              | Distinct.           | Cons.,<br>green.                 | 0.28   | 3.70                            | 1.80                 | .0008    | .0344       | .0220      | .0124           | .19       | .0000          | .0001     | .5160            | 1.3       |
| 11445   | Dec. 5              | Slight.             | Slight.                          | 0.15   | 3.05                            | 1.20                 | .0000    | .0270       | .0204      | .0066           | .17       | .0000          | .0002     | .3978            | 0.9       |
| Av.     | .....               | .....               | .....                            | 0.47   | 4.11                            | 2.03                 | .0011    | .0375       | .0259      | .0116           | .14       | .0019          | .0001     | .5779            | 1.2       |

*Averages of Analyses of Previous Years.*

|   |          |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|----------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1876-77* | - | - | -    | 4.86 | -    | .0139 | .0426 | .0206 | .0130 | -   | -     | -     | -     | -   |
| - | 1887†    | - | - | 0.24 | 3.63 | 1.65 | .0030 | .0486 | -     | -     | .15 | .0019 | -     | -     | -   |
| - | 1888     | - | - | 0.13 | 2.91 | 1.20 | .0019 | .0332 | -     | -     | .12 | .0047 | .0001 | -     | -   |
| - | 1889     | - | - | 0.11 | 2.42 | 1.07 | .0028 | .0461 | .0237 | .0224 | .10 | .0033 | .0002 | -     | -   |
| - | 1890     | - | - | 0.15 | 2.96 | 1.54 | .0029 | .0387 | .0210 | .0177 | .10 | .0065 | .0001 | -     | 0.9 |
| - | 1891     | - | - | 0.31 | 3.27 | 1.20 | .0011 | .0225 | .0147 | .0078 | .09 | .0049 | .0001 | -     | 1.0 |
| - | 1892‡    | - | - | 0.25 | 3.41 | 1.41 | .0006 | .0277 | .0189 | .0088 | .13 | .0049 | .0001 | -     | 1.0 |
| - | 1893§    | - | - | 0.47 | 4.11 | 2.03 | .0011 | .0375 | .0259 | .0116 | .14 | .0019 | .0001 | .5779 | 1.2 |

\* These analyses were made by Prof. William R. Nichols, for the city of Springfield, from samples collected about once a week, between July 1, 1876, and Sept. 30, 1877.

† June to December.

‡ January to September.

§ May to December.

NOTE to analyses of 1893; Iron, .0133. Odor, vegetable, rarely mouldy or unpleasant; on heating the odor is generally stronger. — The samples were collected from the reservoir at depths of one to six feet beneath the surface, generally near the outlet. In July and August the samples were collected near the center of the reservoir.

This reservoir was empty at the beginning of the year and began to fill again on May 9. For record of heights of water on dates when samples of water were collected for analysis, see page 289.

## SPRINGFIELD.

*Microscopical Examination of Water from Ludlow Reservoir.*

[Number of organisms per cubic centimeter.]

|                                       | 1898.      |            |              |              |            |            |            |            |
|---------------------------------------|------------|------------|--------------|--------------|------------|------------|------------|------------|
|                                       | May.       | June.      | July.        | Aug.         | Sept.      | Oct.       | Nov.       | Dec.       |
| Day of examination, . . .             | 17         | 9          | 7            | 17           | 8          | 5          | 10         | 7          |
| Number of sample, . . .               | 10398      | 10488      | 10604        | 10834        | 10675      | 11141      | 11299      | 11445      |
| <b>PLANTS.</b>                        |            |            |              |              |            |            |            |            |
| <b>Diatomaceæ, . . . .</b>            | <b>489</b> | <b>158</b> | <b>56</b>    | <b>238</b>   | <b>488</b> | <b>184</b> | <b>276</b> | <b>7</b>   |
| Asterionella, . . . .                 | 8          | 1          | 0            | 0            | 0          | 0          | 1          | 0          |
| Cyclotella, . . . .                   | 0          | 2          | 0            | 3            | 76         | 0          | 1          | 0          |
| Diatoma, . . . .                      | 0          | 0          | 0            | 6            | 0          | 0          | 4          | 0          |
| Fragilaria, . . . .                   | 0          | 6          | 0            | 0            | 0          | 1          | 0          | 0          |
| Gomphonema, . . . .                   | 0          | 0          | 0            | 2            | 1          | 0          | 1          | 0          |
| Melosira, . . . .                     | 306        | 148        | 56           | 104          | 196        | 114        | 260        | 0          |
| Navicula, . . . .                     | 3          | 1          | 0            | 0            | 0          | 1          | 0          | 0          |
| Synedra, . . . .                      | 80         | 2          | 0            | 124          | 192        | 68         | 8          | 1          |
| Tabellaria, . . . .                   | 2          | 0          | 0            | 0            | 1          | 0          | 1          | 6          |
| <b>Cyanophyceæ, . . . .</b>           | <b>0</b>   | <b>6</b>   | <b>0</b>     | <b>130</b>   | <b>6</b>   | <b>29</b>  | <b>4</b>   | <b>0</b>   |
| Anabaena, . . . .                     | 0          | 6          | 0            | 124          | 6          | 0          | 0          | 0          |
| Chroococcus, . . . .                  | 0          | 0          | 0            | 6            | 0          | 0          | 0          | 0          |
| Merismopedia, . . . .                 | 0          | 0          | 0            | 0            | 0          | 29         | 0          | 0          |
| Microcystis, . . . .                  | 0          | 0          | 0            | 0            | 0          | 0          | 4          | 0          |
| <b>Algae, . . . .</b>                 | <b>142</b> | <b>114</b> | <b>3,928</b> | <b>881</b>   | <b>402</b> | <b>121</b> | <b>39</b>  | <b>3</b>   |
| Botryococcus, . . . .                 | 0          | 0          | 0            | 64           | 96         | 0          | 0          | 0          |
| Chlorococcus, . . . .                 | 0          | 46         | 0            | 0            | 0          | 22         | 0          | 0          |
| Closterium, . . . .                   | 0          | 1          | 3            | 0            | 0          | 0          | 0          | 0          |
| Cocciatrum, . . . .                   | 0          | 0          | 3,840        | 0            | 0          | 0          | 0          | 0          |
| Cosmarium, . . . .                    | 0          | 0          | 0            | 4            | 0          | 0          | 0          | 1          |
| Pandorina, . . . .                    | 1          | 7          | 0            | 0            | 0          | 0          | 0          | 0          |
| Pediastrum, . . . .                   | 0          | 4          | 8            | 0            | 2          | 3          | 2          | 0          |
| Protococcus, . . . .                  | 9          | 0          | 4            | 0            | 10         | 0          | 30         | 0          |
| Raphidium, . . . .                    | 0          | 0          | 2            | 52           | 8          | 8          | 0          | 0          |
| Scenedesmus, . . . .                  | 92         | 38         | 64           | 540          | 240        | 88         | 6          | 2          |
| Sorastrium, . . . .                   | 0          | 3          | 0            | 0            | 4          | 0          | 0          | 0          |
| Staurastrum, . . . .                  | 32         | 7          | 4            | 200          | 40         | 0          | 1          | 0          |
| Tetraspora, . . . .                   | 0          | 6          | 0            | 0            | 0          | 0          | 0          | 0          |
| Zoöspores, . . . .                    | 8          | 2          | 1            | 1            | 2          | 0          | 0          | 0          |
| <b>Fungi, . . . .</b>                 | <b>0</b>   | <b>1</b>   | <b>4</b>     | <b>0</b>     | <b>1</b>   | <b>0</b>   | <b>21</b>  | <b>0</b>   |
| Crenothrix, . . . .                   | 0          | 1          | 4            | 0            | 1          | 0          | 1          | 0          |
| Molds, . . . .                        | 0          | pr.        | 0            | 0            | 0          | 0          | 20         | 0          |
| <b>ANIMALS.</b>                       |            |            |              |              |            |            |            |            |
| <b>Infusoria, . . . .</b>             | <b>8</b>   | <b>28</b>  | <b>0</b>     | <b>100</b>   | <b>21</b>  | <b>8</b>   | <b>8</b>   | <b>140</b> |
| Ciliated Infusorian, . . . .          | 1          | 0          | 0            | 0            | 0          | 0          | 0          | 0          |
| Monas, . . . .                        | 5          | 5          | 0            | 48           | 0          | 0          | 1          | 0          |
| Peridinium, . . . .                   | 1          | 1          | 0            | 0            | 1          | 3          | 7          | 140        |
| Synura, . . . .                       | 1          | 0          | 0            | 0            | 0          | 0          | 0          | 0          |
| Trachelomonas, . . . .                | 0          | 20         | 0            | 62           | 20         | 3          | 1          | 0          |
| <b>Vermes, . . . .</b>                | <b>1</b>   | <b>1</b>   | <b>3</b>     | <b>0</b>     | <b>2</b>   | <b>1</b>   | <b>0</b>   | <b>3</b>   |
| Anurea, . . . .                       | 0          | 1          | 0            | 0            | 2          | 1          | 0          | 0          |
| Monocerca, . . . .                    | 0          | 0          | 3            | 0            | 0          | 0          | 0          | 0          |
| Rotatorian ova, . . . .               | 1          | 0          | 0            | 0            | 0          | 0          | 0          | 1          |
| Rotifer, . . . .                      | 0          | 0          | 0            | 0            | 0          | 0          | 0          | 2          |
| <b>Crustacea, Cyclops, . . . .</b>    | <b>0</b>   | <b>0</b>   | <b>0</b>     | <b>.04</b>   | <b>0</b>   | <b>0</b>   | <b>0</b>   | <b>0</b>   |
| <b>Unidentified, Zoöglæa, . . . .</b> | <b>0</b>   | <b>58</b>  | <b>0</b>     | <b>104</b>   | <b>80</b>  | <b>120</b> | <b>108</b> | <b>33</b>  |
| <b>TOTAL, . . . .</b>                 | <b>640</b> | <b>365</b> | <b>3,989</b> | <b>1,434</b> | <b>958</b> | <b>461</b> | <b>457</b> | <b>186</b> |

## SPRINGFIELD.

*Table showing Heights of Water in Ludlow Reservoir at times when Samples of Water were collected for Analysis in 1893.*

NOTE.—Height of railway, 83 1 feet above bottom of reservoir.

| DATE.    |   |   | Height of Water above Bottom of Reservoir. | DATE.    |   |   | Height of Water above Bottom of Reservoir. |
|----------|---|---|--------------------------------------------|----------|---|---|--------------------------------------------|
| 1893.    |   |   | Feet.                                      | 1893.    |   |   | Feet.                                      |
| May 15,  | . | . | 10.00                                      | Sept. 7, | . | . | 14.50                                      |
| June 6,  | . | . | 11.00                                      | Oct. 4,  | . | . | 14.00                                      |
| July 6,  | . | . | 14.50                                      | Nov. 7,  | . | . | 14.70                                      |
| Aug. 16, | . | . | 14.65                                      | Dec. 6,  | . | . | 15.50                                      |

NOTE.—The height of water in this reservoir in previous years has been given with reference to the bottom of the main pipe leading to the city, which is twenty-three feet below the railway and 10.1 feet higher than the bottom of the reservoir at the dam.

## Chemical Examination of Water from Chapin Pond, Ludlow.

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA.    |        |            |            | NITROGEN AS |           |           |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|-------------|--------|------------|------------|-------------|-----------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Albuminoid. |        |            |            | Chlorine.   | Nitrates. | Nitrites. |
|         |                     |             |            |        |                         |                   | Free.       | Total. | Dissolved. | Suspended. |             |           |           |
| 11531   | 1893.<br>Dec. 20    | V. slight.  | V. slight. | 0.01   | 3.20                    | 0.75              | .0114       | .0110  | .0090      | .0020      | .12         | .0030     | .0000     |
|         |                     |             |            |        |                         |                   |             |        |            |            |             | .1863     | 0.6       |

Iron, .0025. Odor, unpleasant. — The sample was collected from the pond fifty feet from shore and three feet beneath the surface.

## Microscopical Examination.

Algæ, *Scenedesmus*, 420.

## WATER SUPPLY OF STOCKBRIDGE—STOCKBRIDGE WATER COMPANY.

*Chemical Examination of Water from Lake Averic, Stockbridge.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA.    |        |            |            | NITROGEN AS |           |           |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|-------------|--------|------------|------------|-------------|-----------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Albuminoid. |        |            |            | Chlorine.   | Nitrates. | Nitrites. |
|         |                     |             |           |        |                         |                   | Free.       | Total. | Dissolved. | Suspended. |             |           |           |
| 10421   | 1893.<br>May 20     | Slight.     | Slight.   | 0.08   | 5.85                    | 1.20              | .0242       | .0134  | .0112      | .0022      | .06         | .0120     | .0060     |
| 10580   | Aug. 22             | Slight.     | Slight.   | 0.05   | 6.25                    | 1.60              | .0028       | .0102  | .0156      | .0036      | .07         | .0050     | .0000     |
| 11364   | Nov. 21             | V. slight.  | Slight.   | 0.05   | 6.35                    | 1.55              | .0006       | .0170  | .0144      | .0026      | .08         | .0030     | .0000     |
| AV.     | .....               | .....       | .....     | 0.06   | 6.15                    | 1.45              | .0092       | .0165  | .0137      | .0028      | .07         | .0067     | .0020     |
|         |                     |             |           |        |                         |                   |             |        |            |            |             | .2579     | 4.1       |

Iron, .0069. Odor, of the first sample, none, becoming distinctly vegetable on heating; of the second and last samples, distinctly vegetable and unpleasant; of the third sample, faintly vegetable. The odors of the last three samples were unchanged by heating. — The first and last samples were collected from faucets in the pumping station, and represent water from the lake; the second sample, directly from the lake near the pumping station.



**PITTSFIELD.***Chemical Examination of Water from Sachem and Hollow Brooks, Lanesborough.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------|--------|-------------------------|-------------------|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                   |        |                         |                   |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |           |
| 14819   | 1895.<br>Aug. 12    | None.       | V. slight.        | .08    | 8.80                    | 0.70              | .0000    | .0034       | .0016      | .0018           | .07       | .0170       | .0001     | .1248            | 6.9       |
| 15629   | Nov. 27             | Slight.     | Cons.,<br>brown.  | .15    | 7.75                    | 1.40              | .0004    | .0080       | .0060      | .0020           | .07       | .0400       | .0000     | .2224            | 5.1       |
| 14823   | Aug. 12             | None.       | Slight.           | .03    | 6.80                    | 0.50              | .0000    | .0016       | .0012      | .0004           | .09       | .0100       | .0000     | .0468            | 5.3       |
| 15628   | Nov. 27             | Slight.     | Cons.,<br>earthy. | .08    | 3.40                    | 0.75              | .0002    | .0050       | .0042      | .0008           | .10       | .0080       | .0000     | .1328            | 2.1       |

Odor of the first sample, none; of the second, faintly vegetable, becoming stronger on heating; of the third, none, becoming distinctly aromatic on heating; of the last sample, faintly vegetable. — The first two samples were collected from Sachem Brook, a short distance above its junction with Hollow Brook; the last two samples from Hollow Brook, a short distance above its junction with Sachem Brook.

*Microscopical Examination.*

An insignificant number of organisms was found in each of these samples.

*Chemical Examination of Water from Smith and Lulu Brooks, Pittsfield.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 14820   | 1895.<br>Aug. 12    | None.       | V. slight. | .05    | 3.75                            | 0.40                 | .0000    | .0024       | .0016      | .0008           | .08       | .0030          | .0001     | .0858            | 2.7       |
| 15631   | Nov. 27             | None.       | Slight.    | .08    | 2.05                            | 0.60                 | .0000    | .0050       | .0038      | .0012           | .11       | .0000          | .0000     | .1388            | 0.6       |
| 15633   | Nov. 27             | -           | -          | .33    | -                               | -                    | -        | -           | -          | -               | .11       | -              | -         | -                | 2.1       |

Odor, none. — The first two samples were collected from Smith Brook at the second road crossing above West Street, and the last sample from Lulu Brook, at the first road crossing above Onota Lake.

*Microscopical Examination.*

No. 15633 was not examined. An insignificant number of organisms was found in each of the other samples.

## STOUGHTON.

near the well. The watershed of the brook, above a point opposite the well, has an area, as measured from the State map, of 1.83 square miles. Of this area, fully one-third contributes to the supply of Muddy Pond. This portion of the watershed is an elevated and generally level gravelly tract, which contains a great many depressions from which there is no outlet, and the portion of the rainfall which is not evaporated sinks into the ground and reappears in and around Muddy Pond in the form of springs. The remainder of the watershed drains through Leonard Brook and enters Muddy Pond Brook a short distance below the pond.

The pond is about three hundred feet in diameter and is surrounded by swampy land, at the edge of which most of the springs appear.

The well is six feet in diameter and is said to be thirty-nine feet in depth. It is lined with brick work, the portion near the bottom being laid without mortar. Just below the well a puddle cut-off wall was constructed across the valley of the brook, two hundred and forty feet in length and forty feet in depth. The excavation for this wall is said to have been through six feet of clay, thirty to thirty-two feet of gravel, and two to four feet of hard pan. On the upper side of the wall, just above the hard pan, six lines of four-inch tile pipes were laid to the collecting well. Between the well and Muddy Pond, at a point five hundred to six hundred feet above the well, a dam was constructed to flow an area of 34.3 acres to an elevation about twelve feet above the level of the brook at the collecting well. The pond and swampy land before mentioned were included in the area to be flowed. It was thought that this reservoir would increase the supply from the well, but as it was found upon trial that it did not, and the water was of such character that it was not suitable for use if taken directly from the reservoir, it was abandoned.

From the collecting well a twelve-inch cast-iron pipe, 4,263 feet in length, conveys the water to a pump well at the pumping station, which is located on the right or easterly bank of the brook, just above Central Street. The pipe is turned down at both ends and was intended to act as a siphon when the water in the collecting well was lower than the pipe. The pump well is a water-tight wrought iron tank, six feet in diameter and twenty-six feet in depth, and from it water is pumped to the town and to the open iron tank formerly used in connection with the old source of supply.

**STOUGHTON.**

With a view to filtering the water taken from the brook, a small filter, having an area of about one hundred square feet, was constructed near the collecting well. The filter contains five feet in depth of sand and gravel of various degrees of fineness, the coarser material being at the bottom of the filter and the finer at the top. Water from the brook can be turned upon the filter to a maximum depth of two feet.

After it was found that the collecting well would not furnish enough water for the town, application was made to the State Board of Health for advice relative to taking a new source or devising some method of obtaining a larger supply from the present plant. The reply of the Board to this application may be found on page 55 of this volume.

*Chemical Examination of Water from the Stoughton Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 11547   | 1893.<br>Dec. 23    | V. slight.  | Slight.   | 0.70   | 4.05                    | 1.95              | .0024    | .0116       | .0084      | .0032      | .36       | .0200       | .0001     | .6720            | 0.6       |

Iron, .0065. Odor, distinctly vegetable. — The sample was collected from a faucet at the pumping station, at a time when water was being taken from the brook.

*Microscopical Examination.*

Diatomaceæ, *Meridion*, 1; *Pinnularia*, 1; *Synedra*, 20. Fungi, *Crenothrix*, 3. Miscellaneous, *Zoogloæa*, 3. Total, 28.

## WATER SUPPLY OF SWAMPSCOTT AND NAHANT — MARBLEHEAD WATER COMPANY.

The great variation in the quantities of chlorine, total residue, and hardness in this water, is due to the presence of a small quantity of sea water, at times, in the water of some of the wells from which the supply of this company is drawn.

## SWAMPSCOTT AND NAHANT.

*Chemical Examination of Water from the Wells of the Marblehead Water Company, Swampscott.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albu- minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1893.</b>        |             |            |        |                         |          |               |           |             |           |                  |           |       |
| 9861    | Jan. 9              | None.       | None.      | 0.00   | 39.80                   | .0000    | .0028         | 11.08     | .5000       | .0000     | .0400            | 12.4      | .0010 |
| 9991    | Feb. 8              | None.       | None.      | 0.00   | 43.50                   | .0000    | .0026         | 11.00     | .4250       | .0001     | .0547            | 11.6      | .0000 |
| 10104   | Mar. 8              | None.       | None.      | 0.00   | 28.90                   | .0000    | .0000         | 6.30      | .4500       | .0000     | .0252            | 13.6      | .0040 |
| 10226   | Apr. 11             | Slight.     | V. slight. | 0.12   | 9.20                    | .0002    | .0052         | 1.60      | .1000       | .0000     | .2299            | 3.6       | .0120 |
| 10378   | May 9               | None.       | Slight.    | 0.03   | 18.70                   | .0000    | .0040         | 2.98      | .2500       | .0000     | .0547            | 8.1       | .0000 |
| 10494   | June 7              | None.       | None.      | 0.00   | 46.80                   | .0000    | .0026         | 11.60     | .4000       | .0001     | .0657            | 12.4      | .0070 |
| 10606   | July 8              | None.       | None.      | 0.00   | 52.00                   | .0000    | .0012         | 13.24     | .3500       | .0000     | .0803            | 5.9       | .0000 |
| 10767   | Aug. 10             | None.       | None.      | 0.00   | 74.30                   | .0000    | .0000         | 20.60     | .7500       | .0000     | .0632            | 13.4      | .0100 |
| 10997   | Sept. 10            | None.       | None.      | 0.00   | 76.80                   | .0000    | .0022         | 19.84     | .7000       | .0000     | .0858            | 17.2      | .0050 |
| 11175   | Oct. 9              | None.       | None.      | 0.00   | 70.20                   | .0000    | .0012         | 20.84     | .7000       | .0000     | .0972            | 30.6      | .0100 |
| 11313   | Nov. 8              | V. slight.  | V. slight. | 0.02   | 52.40                   | .0000    | .0018         | 14.61     | .0900       | .0002     | .0760            | 25.4      | .0120 |
| 11457   | Dec. 6              | Slight.     | V. slight. | 0.00   | 44.40                   | .0000    | .0022         | 11.80     | .4000       | .0000     | .0234            | 21.8      | .0120 |
| Av.     | .....               | .....       | .....      | 0.01   | 46.42                   | .0000    | .0022         | 12.12     | .4263       | .0000     | .0747            | 14.7      | .0061 |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |       |       |       |       |       |       |       |      |       |
|---|-------|---|---|------|-------|-------|-------|-------|-------|-------|-------|------|-------|
| - | 1837* | - | - | 0.03 | 23.88 | .0032 | .0028 | 2.94  | .5302 | -     | -     | -    | -     |
| - | 1838  | - | - | 0.00 | 25.16 | .0007 | .0035 | 3.26  | .4477 | .0003 | -     | -    | -     |
| - | 1889† | - | - | 0.00 | 26.20 | .0006 | .0033 | 3.80  | .4390 | .0002 | -     | -    | -     |
| - | 1890‡ | - | - | 0.00 | 44.00 | .0006 | .0010 | 8.30  | .6250 | .0001 | -     | 21.2 | -     |
| - | 1891  | - | - | 0.00 | 38.64 | .0018 | .0010 | 7.73  | .9909 | .0002 | -     | 18.0 | -     |
| - | 1892  | - | - | 0.00 | 54.94 | .0000 | .0010 | 14.53 | .7437 | .0000 | -     | 22.0 | -     |
| - | 1893  | - | - | 0.01 | 46.42 | .0000 | .0022 | 12.12 | .4263 | .0000 | .0747 | 14.7 | .0061 |

\* June to December.

† January to May.

‡ October.

NOTE to analyses of 1893; Odor, of No. 10226, faintly earthy; of No. 10378, faintly disagreeable, becoming fainter on heating; of the remaining samples, none. — The samples were collected from a faucet at the pumping station.

*Microscopical Examination.*

A very few organisms were found in the samples collected in April, May, June, October and November. In the remaining samples no organisms were found.

## TAUNTON.

## WATER SUPPLY OF TAUNTON.

Works were nearly completed during the past year for taking an additional supply of water for the city of Taunton from Elder's and Assawompsett ponds in Lakeville. The design of the new works was governed to a large extent by a desire to utilize the more valuable features of the existing works, consisting of a pumping station, in which a new pump had recently been placed, on the bank of the Taunton River, above Taunton, and a filter-basin near the river. The direct-pumping system is used in supplying the city.

The principal features of the new works are a thirty-inch cast-iron pipe about seven miles long for conveying the water by gravity from Elder's Pond to the old pumping station, and a new pumping station and a twenty-four-inch cast-iron force main nearly 6,000 feet in length for lifting and conveying water from Assawompsett Pond into Elder's Pond.

Elder's Pond has an area of 145 acres, a maximum depth of 54.5 feet, and a practically unpopulated, sandy watershed of 195 acres, exclusive of the pond. Its surface is about eighty-six feet above high tide at Taunton, seventy-two feet above the sill of the old pumping station, and thirty-five feet higher than Assawompsett Pond.

Assawompsett Pond, with the exception of the Watuppa lakes the largest body of fresh water in the State, has an area of 2,691 acres, and is the lowest of a chain of ponds comprising also Long, Great Quittacas and Elder's Pond. The total area of the four ponds is 5,652 acres. The area of the watershed above the outlet of Assawompsett Pond, exclusive of the water surfaces of the ponds, is 39.8 square miles.

The water of Assawompsett Pond ranks next to that of Elder's Pond in quality, and the arrangement of the works by which this water would be turned into Elder's Pond before being sent to the city is thought to insure its improvement, both by mingling with the better water in Elder's Pond and by the opportunity afforded it for bleaching while stored in this pond. A suggestion with regard to the further improvement of the water of Assawompsett Pond by filtering it through the natural ground before it entered Elder's Pond is contained in the advice of the Board to the city of Taunton relative to these sources of additional supply, which may be found in the annual report of the State Board of Health for 1891 (page 32).

## TAUNTON.

Provision has been made at the pumping station for conveying the water of Elder's Pond directly to the pumps, to the filter-basin or to the old twenty-inch force main leading to the city. By means of the connection last mentioned water could be supplied under a light pressure to portions of the city by gravity in the event of any accident to the pumps. A twenty-inch blow-off discharging into the Taunton River has also been provided.

When the new works are put in operation the use of the Taunton River as a source of supply will be discontinued, although water may still be drawn from the filter-basin. It is proposed, however, to retain the pipe connecting with the river for use in cases of emergency.

*Chemical Examination of Water from the Filter-Basin of the Taunton Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |       | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|-------------|-----------|-------------|-------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |             |           |             |       |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Sus-pended. |           |             |       |                  |           |
| 1893.   |                     |             |            |        |                         |                   |          |             |            |             |           |             |       |                  |           |
| 9952    | Jan. 30             | V. slight.  | V. slight. | 0.90   | 5.80                    | 1.95              | .0062    | .0212       | .0158      | .0054       | .57       | .0120       | .0001 | .8103            | 1.7       |
| 10057   | Feb. 28             | V. slight.  | V. slight. | 0.50   | 5.00                    | 1.45              | .0008    | .0096       | -          | -           | .56       | .0100       | .0001 | .4572            | 1.9       |
| 10176   | Mar. 28             | None.       | V. slight. | 0.60   | 3.95                    | 1.20              | .0008    | .0092       | -          | -           | .46       | .0150       | .0000 | .4708            | 0.9       |
| 10317   | Apr. 26             | None.       | V. slight. | 0.35   | 5.85                    | -                 | .0000    | .0042       | -          | -           | .56       | .0100       | .0000 | .3248            | 1.6       |
| 10440   | May 23              | V. slight.  | V. slight. | 1.90   | 4.95                    | -                 | .0018    | .0218       | -          | -           | .45       | .0050       | .0000 | 1.2487           | 0.5       |
| 10577   | June 29             | V. slight.  | V. slight. | 1.10   | 5.20                    | -                 | .0004    | .0150       | -          | -           | .49       | .0100       | .0000 | .7939            | 1.1       |
| 10695   | July 25             | V. slight.  | Slight.    | 0.60   | 5.10                    | -                 | .0000    | .0160       | -          | -           | .62       | .0070       | .0001 | .4662            | 1.4       |
| 10915   | Aug. 29             | V. slight.  | Slight.    | 1.10   | 5.60                    | 2.70              | .0004    | .0190       | .0164      | .0026       | .57       | .0150       | .0000 | .9322            | 1.2       |
| 11086   | Sept. 25            | Slight.     | V. slight. | 0.55   | 6.30                    | -                 | .0022    | .0140       | -          | -           | .65       | .0180       | .0000 | .4879            | 1.7       |
| 11234   | Oct. 23             | V. slight.  | Slight.    | 0.60   | 6.00                    | -                 | .0076    | .0154       | -          | -           | .66       | .0050       | .0002 | .3914            | 1.7       |
| 11392   | Nov. 27             | V. slight.  | V. slight. | 0.63   | 5.45                    | -                 | .0078    | .0146       | -          | -           | .68       | .0200       | .0002 | .6751            | 1.8       |
| 11518   | Dec. 18             | Distinct.   | V. slight. | 0.95   | 5.75                    | -                 | .0032    | .0190       | -          | -           | .61       | .0100       | .0000 | 1.0575           | 1.4       |
| Av..    | .....               | .....       | .....      | 0.82   | 5.41                    | 1.82              | .0026    | .0149       | -          | -           | .57       | .0114       | .0001 | .6763            | 1.4       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |   |   |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|---|---|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 0.29 | 5.66 | -    | .0017 | .0092 | - | - | .60 | .0167 | -     | -     | -   |
| - | 1888  | - | - | 0.47 | 5.40 | -    | .0010 | .0120 | - | - | .53 | .0150 | .0001 | -     | -   |
| - | 1889  | - | - | 0.29 | 5.12 | -    | .0012 | .0073 | - | - | .57 | .0185 | .0001 | -     | -   |
| - | 1890  | - | - | 0.35 | 5.91 | -    | .0012 | .0087 | - | - | .57 | .0227 | .0001 | -     | 1.9 |
| - | 1891  | - | - | 0.35 | 5.25 | 3.76 | .0014 | .0073 | - | - | .55 | .0212 | .0000 | -     | 1.7 |
| - | 1892  | - | - | 0.60 | 5.53 | 3.88 | .0005 | .0124 | - | - | .58 | .0147 | .0001 | -     | 1.6 |
| - | 1893  | - | - | 0.82 | 5.41 | 1.82 | .0026 | .0149 | - | - | .57 | .0114 | .0001 | .6763 | 1.4 |

\* June to December.

Note to analyses of 1893; Iron, .0278. Odor, distinctly vegetable and grassy, very rarely unpleasant. — The samples were collected from a faucet at the pumping station while pumping. Water from the Taunton River is admitted directly to the filter-basin whenever the yield of the latter is insufficient for the supply of the city.

## TAUNTON.

*Microscopical Examination of Water from the Filler-Basin of the Taunton Water Works.*

[Number of organisms per cubic centimeter.]

|                                | 1893.      |            |           |           |           |           |           |           |           |           |            |           |
|--------------------------------|------------|------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|-----------|
|                                | Jan.       | Mar.       | Mar.      | Apr.      | May.      | June.     | July.     | Aug.      | Sept.     | Oct.      | Nov.       | Dec.      |
| Day of examination, .          | 31         | 1          | 29        | 27        | 24        | 30        | 26        | 31        | 27        | 24        | 28         | 20        |
| Number of sample, .            | 9952       | 10057      | 10176     | 10317     | 10440     | 10577     | 10695     | 10915     | 11086     | 11234     | 11392      | 11518     |
| <b>PLANTS.</b>                 |            |            |           |           |           |           |           |           |           |           |            |           |
| <b>Diatomaceæ, . .</b>         | <b>4</b>   | <b>6</b>   | <b>25</b> | <b>5</b>  | <b>2</b>  | <b>2</b>  | <b>3</b>  | <b>1</b>  | <b>22</b> | <b>1</b>  | <b>13</b>  | <b>2</b>  |
| Diatoma, . . .                 | 0          | 0          | 2         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 5          | 0         |
| Fragilaria, . .                | 0          | 0          | 12        | 0         | 0         | 0         | 0         | 0         | 20        | 0         | 0          | 0         |
| Melosira, . . .                | 2          | 0          | 6         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 7          | 0         |
| Navicula, . . .                | 2          | 2          | 2         | 2         | 0         | 1         | 2         | 0         | 1         | 0         | pr.        | 0         |
| Synedra, . . .                 | pr.        | 4          | 3         | 3         | 2         | 1         | 1         | 1         | 1         | 1         | 1          | 2         |
| <b>Cyanophyceæ,</b>            |            |            |           |           |           |           |           |           |           |           |            |           |
| Oscillaria, . . .              | 0          | 0          | 0         | 2         | pr.       | 0         | 2         | 0         | 2         | 6         | 2          | 0         |
| <b>Fungi, Crenothrix, .</b>    | <b>pr.</b> | <b>192</b> | <b>1</b>  | <b>0</b>  | <b>8</b>  | <b>10</b> | <b>60</b> | <b>48</b> | <b>12</b> | <b>26</b> | <b>pr.</b> | <b>7</b>  |
| <b>ANIMALS.</b>                |            |            |           |           |           |           |           |           |           |           |            |           |
| <b>Infusoria, . . .</b>        | <b>1</b>   | <b>2</b>   | <b>6</b>  | <b>0</b>  | <b>0</b>  | <b>0</b>  | <b>0</b>  | <b>1</b>  | <b>0</b>  | <b>0</b>  | <b>pr.</b> | <b>0</b>  |
| Dinobryon cases, .             | 0          | pr.        | 2         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0          | 0         |
| Peridinium, . . .              | 1          | 2          | 4         | 0         | 0         | 0         | 0         | 1         | 0         | 0         | pr.        | 0         |
| <i>Miscellaneous, Zoöglæa,</i> | 5          | 72         | 32        | 12        | 0         | 0         | 6         | 28        | 5         | 0         | 2          | 8         |
| <b>TOTAL, . . . .</b>          | <b>10</b>  | <b>272</b> | <b>64</b> | <b>19</b> | <b>10</b> | <b>12</b> | <b>71</b> | <b>78</b> | <b>41</b> | <b>33</b> | <b>17</b>  | <b>17</b> |

*Chemical Examination of Water from the Taunton River at Taunton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1893.   |                     |             |           |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 9951    | Jan. 30             | Slight.     | Slight.   | 1.20   | 6.05                            | 2.20                 | .0064    | .0244       | .0208      | .0036           | .82       | .0090          | .0001     | 1.0249           | 1.5       |
| 10056   | Feb. 28             | Slight.     | Slight.   | 1.10   | 4.95                            | 1.95                 | .0010    | .0184       | .0142      | .0042           | .57       | .0090          | .0001     | .9504            | 1.1       |
| 10175   | Mar. 28             | Slight.     | Slight.   | 1.10   | 3.55                            | 1.80                 | .0006    | .0172       | .0136      | .0036           | .47       | .0100          | .0000     | .8176            | 0.5       |
| 10316   | Apr. 26             | V. slight.  | Slight.   | 1.30   | 4.55                            | 2.15                 | .0009    | .0212       | .0190      | .0022           | .46       | .0050          | .0001     | 1.2045           | 0.6       |
| 10439   | May 23              | Slight.     | Cons.     | 2.50   | 4.95                            | 2.45                 | .0022    | .0290       | .0264      | .0026           | .38       | .0050          | .0000     | 1.6087           | 0.5       |
| 10576   | June 29             | None.       | Slight.   | 1.80   | 5.20                            | 2.95                 | .0006    | .0284       | .0246      | .0038           | .49       | .0070          | .0001     | 1.2403           | 0.9       |
| 10694   | July 25             | V. slight.  | Slight.   | 1.20   | 5.05                            | 2.00                 | .0018    | .0268       | .0236      | .0032           | .61       | .0070          | .0001     | .7326            | 0.8       |
| 10914   | Aug. 29             | V. slight.  | Slight.   | 2.20   | 6.65                            | 3.55                 | .0018    | .0348       | .0318      | .0030           | .52       | .0080          | .0001     | 1.7617           | 1.0       |
| 11087   | Sept. 26            | Slight.     | Slight.   | 0.90   | 3.15                            | 1.70                 | .0116    | .0200       | .0176      | .0024           | .67       | .0120          | .0002     | .6478            | 1.3       |
| 11233   | Oct. 23             | Slight.     | Slight.   | 0.90   | 6.70                            | 2.55                 | .0212    | .0238       | .0160      | .0078           | .70       | .0030          | .0005     | .5320            | 1.3       |
| 11391   | Nov. 27             | Slight.     | Slight.   | 1.00   | 5.55                            | 2.05                 | .0008    | .0220       | .0202      | .0018           | .72       | .0100          | .0004     | 1.1266           | 1.6       |
| 11517   | Dec. 18             | Distinct.   | Cons.     | 1.35   | 5.60                            | 2.35                 | .0030    | .0294       | .0262      | .0032           | .54       | .0080          | .0001     | 1.3365           | 1.1       |
| Av.,    | .....               | .....       | .....     | 1.38   | 5.33                            | 2.31                 | .0043    | .0246       | .0212      | .0034           | .56       | .0078          | .0002     | 1.0820           | 1.1       |

## TAUNTON.

*Chemical Examination of Water from the Taunton River at Taunton—Concluded.**Averages of Analyses of Previous Years.*

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| -       | 1887*               | -           | -         | 1.29   | 5.84                    | 2.09              | .0030    | .0285       | -          | -          | .59       | .0097       | -         | -                | -         |
| -       | 1888                | -           | -         | 1.51   | 5.25                    | 2.28              | .0016    | .0294       | -          | -          | .44       | .0086       | .0001     | -                | -         |
| -       | 1889                | -           | -         | 1.67   | 4.50                    | 2.17              | .0015    | .0304       | .0270      | .0034      | .45       | .0085       | .0001     | -                | -         |
| -       | 1890                | -           | -         | 1.31   | 5.36                    | 2.27              | .0016    | .0254       | .0225      | .0029      | .48       | .0118       | .0001     | -                | 1.3       |
| -       | 1891                | -           | -         | 1.12   | 4.77                    | 1.98              | .0006    | .0220       | .0197      | .0023      | .47       | .0095       | .0001     | -                | 1.0       |
| -       | 1892                | -           | -         | 1.08   | 5.27                    | 2.20              | .0012    | .0225       | .0198      | .0027      | .54       | .0093       | .0001     | -                | 1.1       |
| -       | 1893                | -           | -         | 1.38   | 5.33                    | 2.31              | .0043    | .0246       | .0212      | .0034      | .56       | .0078       | .0002     | 1.0820           | 1.1       |

\* June to December.

NOTE to analyses of 1893; Iron, .0302. Odor, decidedly vegetable and sweetish, rarely mouldy or unpleasant. — The samples were collected from the river opposite the filter-basin of the Taunton Water Works.

*Microscopical Examination of Water from the Taunton River at Taunton.*

[Number of organisms per cubic centimeter.]

|                           | 1893. |       |       |       |       |       |       |       |       |       |       |       |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                           | Jan.  | Mar.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination,       | 31    | 1     | 29    | 27    | 24    | 30    | 26    | 31    | 27    | 24    | 28    | 20    |
| Number of sample,         | 9951  | 10056 | 10175 | 10316 | 10439 | 10576 | 10694 | 10914 | 11087 | 11233 | 11391 | 11517 |
| PLANTS.                   |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . .           | 2     | 11    | 21    | 145   | 7     | 6     | 6     | 7     | 2     | 3     | 13    | 6     |
| Fragilaria, . . .         | 0     | 4     | 6     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Melosira, . . .           | 1     | 1     | 1     | 4     | 3     | 0     | 0     | 0     | 0     | 0     | 1     | 0     |
| Meridion, . . .           | 0     | 1     | 8     | 2     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Navicula, . . .           | 0     | 4     | pr.   | 1     | 0     | 0     | 1     | 2     | 1     | 1     | 0     | 2     |
| Synedra, . . .            | 1     | 1     | 6     | 134   | 1     | 3     | 4     | 5     | 0     | 2     | 3     | 4     |
| Tabellaria, . .           | pr.   | pr.   | 0     | 4     | 2     | 3     | 1     | 0     | 1     | 0     | 9     | 0     |
| Fungi, Crenothrix, .      | 4     | 1     | 3     | 32    | 64    | 5     | 5     | 80    | 2     | 2     | 4     | 9     |
| ANIMALS.                  |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . .          | 1     | 4     | 17    | 0     | 0     | 0     | 0     | 1     | 0     | 1     | 2     | 0     |
| Dinobryon, . . .          | 0     | 3     | 11    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, .        | 0     | pr.   | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     |
| Peridinium, . . .         | 1     | 1     | 4     | 0     | 0     | 0     | 0     | 1     | 0     | 1     | pr.   | 0     |
| Miscellaneous, Zoöglæa, . | 15    | 5     | 42    | 108   | 30    | 24    | 13    | 88    | 24    | 10    | 2     | 56    |
| TOTAL, . . .              | 22    | 21    | 83    | 285   | 101   | 35    | 24    | 176   | 28    | 16    | 21    | 71    |



## TAUNTON.

*Chemical Examination of Water from Elder's Pond, Lakeville.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1893.   |                     |             |           |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 10186   | Mar. 29             | Slight.     | Slight.   | 0.01   | 2.05                    | 1.00              | .0000    | .0152       | .0148      | .0004      | .42       | .0070       | .0000     | .1241            | 0.5       |
| 10581   | June 30             | V. slight.  | Cons.     | 0.02   | 1.75                    | 0.45              | .0000    | .0206       | .0138      | .0068      | .37       | .0000       | .0000     | .1580            | 0.3       |
| 11520   | Dec 18              | V. slight.  | Slight.   | 0.00   | 1.85                    | 0.75              | .0000    | .0168       | .0152      | .0016      | .39       | .0030       | .0000     | .1498            | 0.2       |
| Av.     | .....               | .....       | .....     | 0.01   | 1.88                    | 0.73              | .0000    | .0175       | .0146      | .0029      | .39       | .0033       | .0000     | .1440            | 0.3       |

Iron, .0008. Odor of the first sample, none; of the others, vegetable. — The samples were collected from the pond in the vicinity of the gate house of the Taunton Water Works.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 10186, 19; No. 10581, 135; No. 11520, 19.

*Chemical Examination of Water from Assawompsett Pond, Lakeville.*

[Parts per 100,000.]

| No. of<br>bottles. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|--------------------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                    |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|                    |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1893.              |                     |             |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 10187              | Mar. 20             | Distinct.   | Slight.    | 0.50   | 3.10                            | 1.35                 | .0000    | .0200       | .0130      | .0070           | .47       | .0050          | .0000     | .5183            | 0.5       |
| 10589              | June 30             | V. slight.  | V. slight. | 0.30   | 3.35                            | 1.70                 | .0000    | .0148       | .0122      | .0026           | .44       | .0050          | .0000     | .5609            | 0.3       |
| 11519              | Dec. 18             | Slight.     | V. slight. | 0.12   | 2.55                            | 1.00                 | .0006    | .0168       | .0156      | .0012           | .55       | .0030          | .0000     | .4131            | 0.3       |
| Av.                | .....               | .....       | .....      | 0.31   | 3.00                            | 1.35                 | .0002    | .0172       | .0136      | .0036           | .49       | .0043          | .0000     | .4974            | 0.4       |

Iron, .0006. Odor, distinctly vegetable. — The samples were collected from the pond near the surface and 300 to 400 feet from the shore.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 10187, 362, chiefly *Dinobryon*; No. 10589, 51, chiefly *Melosira*; No. 11519, 105, chiefly *Asterionella*.

## WATER SUPPLY OF UXBRIDGE.

The advice of the State Board of Health to the town of Uxbridge with reference to an additional water supply which it was proposed to take from either Seagrave or Cold Spring Brook in Uxbridge or from Mendon Pond in Mendon, together with the opinion of the Board as to the relative merits of these sources, can be found on page 57 of this volume. Further reference to Mendon Pond as a source of water supply for Mendon and Uxbridge can be found on

## UXBRIDGE.

page 39 of this volume, and on page 46 of the annual report of the Board for 1892.

Analyses of samples of water from these sources are given in the following tables.

*Chemical Examination of Water from Cold Spring and Seagrave Brooks, Uxbridge.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. |           |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. | Oxygen Consumed. | Hardness. |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1893.   |                     |             |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 10159   | Mar. 25             | None.       | V. slight. | 0.50   | 2.40                            | 1.15                 | .0002    | .0070       | .0050      | .0020           | .14       | .0000          | .0000     | .4599            | 0.5       |
| 10160   | Mar. 25             | None.       | Slight.    | 0.68   | 2.46                            | 0.75                 | .0000    | .0084       | .0066      | .0018           | .16       | .0000          | .0000     | .4891            | 0.1       |

Iron in the first sample, .0000; in the last, .0050. Odor of the first sample, distinctly vegetable; of the last, faintly vegetable, becoming stronger on heating — The first sample was collected from Cold Spring Brook at the point where it is crossed by the Old Douglas road, between Uxbridge and East Douglass; the last sample, from Seagrave Brook at the point where it was proposed to divert the water, a little less than a mile above its junction with Emerson Brook.

*Microscopical Examination.*

No. 10159. Diatomaceæ, *Meridion*, 2. Miscellaneous, *Zoëglæa*, 26. Total, 28.

No. 10190. Diatomaceæ, *Diatoma*, 3; *Fragilaria*, 4; *Gomphonema*, 2; *Meridion*, 26; *Naricula*, 1; *Synedra*, 2. Miscellaneous, *Zoëglæa*, 20. Total, 68.

*Chemical Examination of Water from Mendon Pond, Mendon.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | NITROGEN<br>AS |           | Oxygen Consumed. |                  |           |  |  |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|----------------|-----------|------------------|------------------|-----------|--|--|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 | Chlorine.      | Nitrates. | Nitrites.        | Oxygen Consumed. | Hardness. |  |  |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |                |           |                  |                  |           |  |  |
| 1893.   |                     |             |            |        |                                 |                      |          |             |            |                 |                |           |                  |                  |           |  |  |
| 10458   | May 30              | V. slight.  | V. slight. | 0.08   | 2.70                            | 1.10                 | .0000    | .0096       | .0080      | .0016           | .26            | .0000     | .0000            | .2550            | 0.3       |  |  |
| 10575   | June 29             | None.       | V. slight. | 0.03   | 1.65                            | 1.05                 | .0000    | .0134       | .0110      | .0024           | .23            | .0000     | .0000            | .2093            | 0.3       |  |  |
| 10664   | July 14             | None.       | V. slight. | 0.03   | 2.00                            | 1.05                 | .0000    | .0150       | .0126      | .0024           | .25            | .0030     | .0000            | .1460            | 0.1       |  |  |
| 10665   | July 14             | V. slight.  | Slight.    | 0.05   | 2.00                            | 0.85                 | .0010    | .0162       | .0132      | .0030           | .24            | .0030     | .0000            | .1638            | 0.1       |  |  |
| 10928   | Aug. 30             | Distinct.   | Slight.    | 0.03   | 2.20                            | 1.10                 | .0000    | .0114       | .0094      | .0020           | .25            | .0030     | .0000            | .2528            | 0.2       |  |  |
| 10929   | Aug. 30             | Slight.     | Slight.    | 0.03   | 2.35                            | 1.30                 | .0000    | .0126       | .0090      | .0036           | .25            | .0000     | .0000            | .2646            | 0.2       |  |  |
| 10930   | Aug. 30             | Slight.     | Slight.    | 0.03   | 2.35                            | 1.20                 | .0000    | .0108       | .0090      | .0018           | .24            | .0000     | .0000            | .2528            | 0.2       |  |  |
| 11095   | Sept. 26            | Slight.     | V. slight. | 0.08   | 2.35                            | 1.00                 | .0000    | .0110       | .0090      | .0020           | .23            | .0000     | .0000            | .2337            | 0.8       |  |  |
| 11251   | Oct. 24             | V. slight.  | Slight.    | 0.10   | 3.95                            | 1.80                 | .0008    | .0136       | .0108      | .0028           | .24            | .0030     | .0000            | .1710            | 0.2       |  |  |
| 11404   | Nov. 27             | Distinct.   | Cons.      | 0.08   | 2.10                            | 0.85                 | .0006    | .0140       | .0114      | .0026           | .21            | .0030     | .0000            | .2193            | 0.8       |  |  |
| 11539   | Dec. 21             | Slight.     | Cons.      | 0.05   | 2.05                            | 0.85                 | .0004    | .0164       | .0134      | .0030           | .23            | .0000     | .0000            | .2511            | 0.5       |  |  |
| Av.*    | .....               | .....       | .....      | 0.06   | 2.39                            | 1.10                 | .0003    | .0132       | .0107      | .0025           | .24            | .0013     | .0000            | .2189            | 0.4       |  |  |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

Iron, .0043. Odor, generally faintly vegetable or none, rarely mouldy or disagreeable; on heating, the odor is somewhat stronger and frequently mouldy. — The samples were collected from the pond within three feet of the surface, with the exception of Nos. 10665 and 10930, which were collected at depths of fourteen and one-half and twelve and one-half feet respectively beneath the surface.

## UXBRIDGE.

*Microscopical Examination of Water from Mendon Pond, Mendon.*

[Number of organisms per cubic centimeter.]

|                           | 1893. |       |       |       |       |       |       |       |       |       |       |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                           | June. | June. | July. | July. | Aug.  | Aug.  | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . | 1     | 30    | 15    | 15    | 31    | 31    | 31    | 28    | 25    | 28    | 23    |
| Number of sample, . . .   | 10455 | 10575 | 10664 | 10665 | 10928 | 10929 | 10930 | 11095 | 11251 | 11404 | 11539 |
| <b>PLANTS.</b>            |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .         | 7     | 10    | 8     | 8     | 1     | 15    | 26    | 71    | 420   | 1,990 | 1,697 |
| Asterionella, . . .       | 0     | 0     | 0     | 0     | 0     | 12    | 15    | 56    | 27    | 370   | 47    |
| Synedra, . . .            | 4     | 10    | 0     | 0     | pr.   | 0     | 0     | 1     | 13    | 20    | 10    |
| Tabellaria, . . .         | 3     | 0     | 8     | 6     | 1     | 3     | 11    | 14    | 380   | 1,600 | 1,640 |
| Cyanophyceæ,              |       |       |       |       |       |       |       |       |       |       |       |
| Merismopedia, . . .       | 0     | 0     | 0     | 0     | 6     | 4     | 10    | 0     | 0     | 0     | 0     |
| Algae, . . .              | 83    | 11    | 0     | 8     | 22    | 26    | 21    | 194   | 15    | 10    | 0     |
| Botryococcus, . . .       | 0     | 0     | 0     | 0     | 12    | 5     | 10    | 0     | 0     | 0     | 0     |
| Chlorococcus, . . .       | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 0     | 0     |
| Protooccus, . . .         | 69    | 9     | 0     | 0     | 0     | 5     | 0     | 0     | 10    | 9     | 0     |
| Raphidium, . . .          | 11    | 2     | 0     | 5     | 9     | 14    | 11    | 192   | 0     | 0     | 0     |
| Staurostrum, . . .        | pr.   | pr.   | 0     | 3     | 1     | 2     | pr.   | 2     | 1     | 1     | 0     |
| <b>ANIMALS.</b>           |       |       |       |       |       |       |       |       |       |       |       |
| Rhizopoda, Actinophrys, . | 12    | 0     | 0     | 0     | 12    | 4     | 2     | 0     | 3     | 1     | 0     |
| Infusoria, . . .          | 0     | 36    | 40    | 190   | pr.   | 9     | 3     | 3     | 0     | 8     | 0     |
| Dinobryon cases, . .      | 0     | 0     | 0     | 184   | 0     | 6     | 1     | 0     | 0     | 8     | 0     |
| Monas, . . .              | pr.   | 0     | 0     | 0     | 0     | pr.   | 0     | 1     | 0     | 0     | 0     |
| Peridinium, . . .         | 0     | 36    | 40    | 6     | pr.   | 3     | 2     | 2     | 0     | 0     | 0     |
| Vermes, Polyanthra, . .   | 0     | 0     | 0     | 0     | 0     | 0     | pr.   | 1     | 0     | 0     | 0     |
| Crustacea, Cyclops, . .   | 0     | 0     | 0     | 0     | 0     | .03   | .04   | 0     | 0     | 0     | .02   |
| Miscellaneous, . . .      | 3     | 16    | 0     | 20    | 30    | 32    | 44    | 32    | 1     | 5     | 0     |
| Acarina, . . .            | 0     | 0     | 0     | 0     | 0     | .06   | .08   | 0     | 0     | 0     | 0     |
| Zoëglæa, . . .            | 3     | 16    | 0     | 20    | 30    | 32    | 44    | 32    | 1     | 5     | 0     |
| TOTAL, . . .              | 105   | 73    | 48    | 224   | 71    | 90    | 106   | 301   | 439   | 2,014 | 1,697 |

## UXBRIDGE.

*Chemical Examination of Water from Meadow Brook, Mendon.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed.<br>Hardness. |     |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|-------------------------------|-----|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                               |     |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                               |     |
| 10161   | 1893.<br>Mar. 25    | None.       | V. slight. | 0.38   | 2.40                            | 0.80                 | .0008    | .0102       | .0074      | .0028           | .09       | .0030          | .0001     | .3650                         | 0.5 |

Iron, .0000. Odor, decidedly vegetable and grassy. — The sample was collected from the brook, which is the outlet of Mendon Pond, at Robinson's saw mill, about a mile below the pond.

*Microscopical Examination.*Miscellaneous, *Zoöglæa*, 20.*Chemical Examination of Water from Mumford River, at Uxbridge.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. |           |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. | Oxygen Consumed. | Hardness. |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 10718   | 1893.<br>Aug. 2     | Slight.     | Slight.   | 0.45   | 2.75                    | 1.00              | .0000    | .0172       | .0148      | .0024      | .24       | .0050       | .0001     | .2590            | 1.1       |

Iron, .0350. Odor, distinctly mouldy and disagreeable, becoming stronger on heating. — The sample was collected from Capron's Pond, a mill pond on the Mumford River, in the village of Uxbridge.

*Microscopical Examination.*

Diatomaceæ, *Epithemia*, 1; *Stauroneis*, 1; *Synedra*, 28; *Tabellaria*, 8. Cyanophyceæ, *Merismopedla*, 4. Algæ, *Cosmarium*, 1; *Raphidium*, 4. Fungi, *Crenothrix*, 8. Infusoria, *Trachelomonas*, 1. Miscellaneous, *Zoöglæa*, 156. Total, 212.

## WATER SUPPLY OF WAKEFIELD AND STONEHAM — WAKEFIELD WATER COMPANY.

The advice of the State Board of Health to the Wakefield Water Company, with reference to obtaining an additional water supply from the valley of Saugus River and its tributaries, within the limits of the town of Wakefield, may be found on page 58 of this volume.

**WAKEFIELD AND STONEHAM.**

The advice of the Board to the city of Lynn with reference to taking an additional supply of water from the valley of the Saugus River and its tributaries, may be found on page 25.

*Chemical Examination of Water from Crystal Lake, Wakefield.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                  |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |           |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------------|--------|---------------------------------|----------------------|----------|-------------|-----------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.        | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |           |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |                  |        |                                 |                      |          | Total.      | Dissolved | Sus-<br>pended. |           |                |           |                  |           |
|         | <b>1893.</b>        |             |                  |        |                                 |                      |          |             |           |                 |           |                |           |                  |           |
| 10007   | Feb. 13             | Slight.     | V. slight.       | 0.03   | 2.30                            | 0.75                 | .0124    | .0126       | .0110     | .0016           | .39       | .0200          | .0001     | .1788            | 0.9       |
| 10250   | Apr. 12             | Distinct.   | Cons.,<br>white. | 0.08   | 4.25                            | 1.00                 | .0014    | .0138       | .0122     | .0016           | .52       | .0300          | .0001     | .2372            | 1.7       |
| 10518   | June 14             | Slight.     | Slight.          | 0.20   | 3.85                            | 1.65                 | .0018    | .0206       | .0172     | .0034           | .64       | .0050          | .0000     | .3182            | 1.3       |
| 10864   | Aug. 18             | Distinct.   | Slight.          | 0.18   | 4.35                            | 1.70                 | .0000    | .0192       | .0172     | .0020           | .60       | .0000          | .0001     | .3120            | 1.6       |
| 11199   | Oct. 16             | Slight.     | Slight.          | 0.18   | 4.05                            | 1.20                 | .0004    | .0176       | .0154     | .0022           | .64       | .0030          | .0000     | .3078            | 1.7       |
| 11479   | Dec. 12             | Slight.     | Slight.          | 0.15   | 3.90                            | 1.10                 | .0000    | .0152       | .0198     | .0044           | .61       | .0080          | .0000     | .2416            | 1.6       |
| 11507   | Dec. 18             | V. slight.  | Slight.          | 0.15   | 4.20                            | 1.50                 | .0014    | .0136       | .0122     | .0014           | .63       | .0050          | .0000     | .2163            | 1.7       |
| Av.*    | .....               | .....       | .....            | 0.14   | 3.81                            | 1.27                 | .0028    | .0164       | .0141     | .0023           | .57       | .0108          | .0001     | .2638            | 1.5       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887† | - | - | 0.17 | 3.73 | 0.91 | .0006 | .0174 | -     | -     | .51 | .0043 | -     | -     | -   |
| - | 1888‡ | - | - | 0.13 | 3.60 | 0.92 | .0009 | .0167 | -     | -     | .48 | .0080 | .0001 | -     | -   |
| - | 1889§ | - | - | 0.10 | 3.60 | 0.87 | .0009 | .0141 | .0119 | .0022 | .49 | .0163 | .0002 | -     | -   |
| - | 1890  | - | - | 0.25 | 4.22 | 1.35 | .0001 | .0371 | .0190 | .0181 | .46 | .0090 | .0001 | -     | 1.8 |
| - | 1891¶ | - | - | 0.08 | 4.17 | 1.50 | .0003 | .0160 | .0129 | .0031 | .47 | .0145 | .0001 | -     | 1.6 |
| - | 1893  | - | - | 0.14 | 3.81 | 1.27 | .0028 | .0164 | .0141 | .0023 | .57 | .0108 | .0001 | .2638 | 1.5 |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

† June to December.

‡ January to October.

§ January, March and June.

|| Three in October.

¶ May and November.

NOTE to analyses of 1893; Iron, .0109. Odor, generally faintly vegetable, rarely none; in June, disagreeable; on heating, the odor is generally considerably stronger, and in the April sample was oily or fishy. — The first sample was collected from the pond; the remaining samples, from faucets.

## WAKEFIELD AND STONEHAM.

*Microscopical Examination of Water from Crystal Lake, Wakefield.*

[Number of organisms per cubic centimeter.]

|                                          | 1893.     |           |              |            |            |            |            |
|------------------------------------------|-----------|-----------|--------------|------------|------------|------------|------------|
|                                          | Feb.      | April.    | June.        | Aug.       | Oct.       | Dec.       | Dec.       |
| Day of examination, . . . . .            | 15        | 14        | 15           | 19         | 17         | 13         | 19         |
| Number of sample, . . . . .              | 10007     | 10250     | 10518        | 10864      | 11199      | 11479      | 11507      |
| <b>PLANTS.</b>                           |           |           |              |            |            |            |            |
| <b>Diatomaceæ, . . . . .</b>             | <b>0</b>  | <b>7</b>  | <b>1,199</b> | <b>18</b>  | <b>514</b> | <b>275</b> | <b>132</b> |
| Asterionella, . . . . .                  | 0         | 1         | 0            | 0          | 64         | 68         | 53         |
| Cyclotella, . . . . .                    | 0         | 1         | 44           | 1          | 36         | 28         | 47         |
| Diatoma, . . . . .                       | 0         | 0         | 0            | 0          | 12         | 0          | 0          |
| Fragilaria, . . . . .                    | 0         | 0         | 34           | 0          | 30         | 23         | 0          |
| Melosira, . . . . .                      | 0         | 0         | 1            | 3          | 30         | 0          | 0          |
| Synedra, . . . . .                       | 0         | 3         | 1,120        | 0          | 0          | 2          | 0          |
| Tabellaria, . . . . .                    | 0         | 2         | 0            | 14         | 342        | 152        | 32         |
| <b>Cyanophyceæ, . . . . .</b>            | <b>0</b>  | <b>0</b>  | <b>14</b>    | <b>104</b> | <b>11</b>  | <b>0</b>   | <b>0</b>   |
| Anabæna, . . . . .                       | 0         | 0         | 14           | 28         | 0          | 0          | 0          |
| Anabæna spores, . . . . .                | 0         | 0         | 0            | 20         | 0          | 0          | 0          |
| Chroococcus, . . . . .                   | 0         | 0         | 0            | 0          | 4          | 0          | 0          |
| Clathrocystis, . . . . .                 | 0         | 0         | 0            | 28         | 0          | 0          | 0          |
| Microcystis, . . . . .                   | 0         | 0         | 0            | 28         | 7          | 0          | 0          |
| <b>Algæ, . . . . .</b>                   | <b>0</b>  | <b>0</b>  | <b>82</b>    | <b>124</b> | <b>0</b>   | <b>0</b>   | <b>0</b>   |
| Pandorina, . . . . .                     | 0         | 0         | 4            | 0          | 0          | 0          | 0          |
| Protococcus, . . . . .                   | 0         | 0         | 54           | 124        | 0          | 0          | 0          |
| Scenedesmus, . . . . .                   | 0         | 0         | 24           | 0          | 0          | 0          | 0          |
| <b>Fungi, Crenothrix, . . . . .</b>      | <b>0</b>  | <b>0</b>  | <b>0</b>     | <b>0</b>   | <b>5</b>   | <b>1</b>   | <b>0</b>   |
| <b>ANIMALS.</b>                          |           |           |              |            |            |            |            |
| <b>Rhizopoda, Arcella, . . . . .</b>     | <b>0</b>  | <b>2</b>  | <b>0</b>     | <b>0</b>   | <b>0</b>   | <b>0</b>   | <b>0</b>   |
| <b>Infusoria, . . . . .</b>              | <b>0</b>  | <b>7</b>  | <b>2</b>     | <b>8</b>   | <b>33</b>  | <b>0</b>   | <b>0</b>   |
| Dinobryon, . . . . .                     | 0         | 0         | 0            | 4          | 5          | 0          | 0          |
| Dinobryon cases, . . . . .               | 0         | 0         | 0            | 0          | 8          | 0          | 0          |
| Euglena, . . . . .                       | 0         | 0         | 0            | 1          | 0          | 0          | 0          |
| Peridinium, . . . . .                    | 0         | 7         | pr.          | 1          | 0          | 0          | 0          |
| Synura, . . . . .                        | 0         | 0         | 2            | 0          | 0          | 0          | 0          |
| Trachelomonas, . . . . .                 | 0         | 0         | 0            | 2          | 20         | 0          | 0          |
| <b>Miscellaneous, Zoöglæa, . . . . .</b> | <b>52</b> | <b>20</b> | <b>26</b>    | <b>28</b>  | <b>16</b>  | <b>3</b>   | <b>0</b>   |
| <b>TOTAL, . . . . .</b>                  | <b>52</b> | <b>36</b> | <b>1,323</b> | <b>282</b> | <b>579</b> | <b>279</b> | <b>132</b> |

## WALPOLE.

The advice of the State Board of Health to the town of Walpole with reference to taking a water supply from the ground near the Neponset River, or tributaries thereof, within the limits of the town, may be found on page 60 of this volume. Analyses of samples of water collected from tubular test wells near the Neponset River are given in the following table.

**WALPOLE.***Chemical Examination of Water from Tubular Test Wells near the Neponset River, in Walpole.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |             |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-------------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.   | Color. |                         | Free.    | Albu- minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1893.</b>        |             |             |        |                         |          |               |           |             |           |                  |           |       |
| 10270   | Apr. 19             | None.       | None.       | 0.02   | 4.00                    | .0002    | .0004         | .33       | .0100       | .0000     | .0000            | 0.8       | .0020 |
| 10271   | Apr. 19             | None.       | Cons. sand. | 0.00   | 5.70                    | .0002    | .0004         | .36       | .1000       | .0000     | .0146            | 1.1       | .0110 |

Odor, none. — The samples were collected from tubular test wells on the easterly side of the Neponset River about one mile south of the village of Walpole. The first sample was collected from Well No. 1, twenty feet in depth, located about seventy-five feet from the Neponset River and about seven hundred and fifty feet down stream (northerly) from the mouth of Low Brook; the last sample, from Well No. 2, thirty feet in depth, located about ninety feet from the Neponset River and about fifteen feet northerly from Low Brook.

*Microscopical Examination.*

No. 10270. No organisms.

No. 10271. Diatomaceæ, *Synedra*, 1.**WATER SUPPLY OF WALTHAM.**

Much trouble has been caused in recent years by the rapid growth of certain low forms of vegetation in the filter-basin and well of the Waltham water works, and with a view to preventing this growth the filter-basin and well were covered in the autumn of 1893. The work was completed before the November and December samples were collected, and the improvement in the quality of the water may be seen by examining the tables of analyses which follow. Reference is also made to the character of the well water in a reply of the State Board of Health to the Water Commissioners of Waltham, which can be found on page 61 of this volume. The distributing reservoir has not been covered, so that the quality of the portion of the water supply of the city which passes through it is affected as in the past by the abundant growths of microscopic organisms.

The filter-basin before being covered had the shape of a rectangle with one corner cut off, and an area of about ten thousand square feet. The well, which is located in the centre of the filter-basin, is forty feet in diameter and is covered with a dome made of flat tiles laid in Portland cement. The portion of the filter-basin outside of the well is covered with a series of brick arches. The shape and size of the filter-basin were not materially changed.

## WALTHAM.

*Chemical Examination of Water from the Well and Filter-Basin of the Waltham Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         |                     |             |            |        |                         |          |                  |           |             |           |                  |           |       |
| 1893.   |                     |             |            |        |                         |          |                  |           |             |           |                  |           |       |
| 9863    | Jan. 10             | None.       | None.      | .00    | 6.95                    | .0048    | .0032            | .48       | .0180       | .0000     | .0720            | 3.5       | .0000 |
| 9930    | Jan. 24             | Slight.     | Cons.      | .02    | 6.85                    | .0072    | .0098            | .50       | .0220       | .0001     | .0657            | 3.4       | .0160 |
| 10006   | Feb. 13             | None.       | None.      | .02    | 6.30                    | .0036    | .0032            | .51       | .0200       | .0000     | .0620            | 3.6       | .0000 |
| 10046   | Feb. 28             | None.       | None.      | .02    | 6.95                    | .0024    | .0026            | .48       | .0100       | .0000     | .0763            | 3.5       | .0000 |
| 10109   | Mar. 13             | None.       | None.      | .00    | 6.25                    | .0020    | .0034            | .57       | .0180       | .0003     | .0688            | 3.8       | .0000 |
| 10171   | Mar. 27             | None.       | V. slight. | .02    | 6.65                    | .0026    | .0018            | .46       | .0180       | .0001     | .0657            | 3.2       | .0000 |
| 10236   | Apr. 11             | None.       | V. slight. | .00    | 6.45                    | .0030    | .0026            | .41       | .0250       | .0000     | .0876            | 3.0       | .0030 |
| 10323   | Apr. 26             | None.       | None.      | .00    | 6.65                    | .0014    | .0012            | .45       | .0180       | .0000     | .0620            | 3.1       | .0000 |
| 10391   | May 15              | None.       | None.      | .00    | 6.90                    | .0038    | .0016            | .47       | .0180       | .0000     | .0474            | 3.0       | .0000 |
| 10514   | June 13             | V. slight.  | None.      | .00    | 7.20                    | .0034    | .0018            | .50       | .0300       | .0000     | .0368            | 3.1       | .0000 |
| 10652   | July 12             | None.       | None.      | .00    | 6.80                    | .0048    | .0022            | .45       | .0120       | .0000     | .0365            | 3.5       | .0025 |
| 10805   | Aug. 15             | None.       | None.      | .00    | 6.80                    | .0022    | .0010            | .44       | .0200       | .0000     | .0592            | 3.2       | .0000 |
| 11020   | Sept. 13            | None.       | None.      | .00    | 6.75                    | .0032    | .0024            | .46       | .0200       | .0000     | .0624            | 3.4       | .0000 |
| 11161   | Oct. 10             | None.       | None.      | .03    | 7.45                    | .0060    | .0022            | .48       | .0070       | .0000     | .0462            | 3.8       | .0050 |
| 11331   | Nov. 14             | None.       | V. slight. | .00    | 7.05                    | .0030    | .0010            | .48       | .0180       | .0000     | .1369            | 3.4       | .0050 |
| 11474   | Dec. 12             | None.       | None.      | .00    | 6.55                    | .0030    | .0008            | .48       | .0150       | .0000     | .0664            | 3.5       | .0025 |
| Av.*    | .....               | .....       | .....      | .01    | 6.86                    | .0036    | .0022            | .47       | .0179       | .0000     | .0643            | 3.4       | .0020 |

*Averages of Analyses of Previous Years.*

|   |       |   |   |     |      |       |       |     |       |       |       |     |       |
|---|-------|---|---|-----|------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1887† | - | - | .00 | 6.71 | .0007 | .0038 | .47 | .0250 | -     | -     | -   | -     |
| - | 1888  | - | - | .00 | 6.70 | .0009 | .0054 | .46 | .0273 | .0003 | -     | -   | -     |
| - | 1889‡ | - | - | .00 | 6.43 | .0006 | .0034 | .48 | .0378 | .0002 | -     | -   | -     |
| - | 1890§ | - | - | .00 | -    | .0000 | .0012 | .47 | .0380 | .0002 | -     | -   | -     |
| - | 1892  | - | - | .00 | 6.81 | .0033 | .0027 | .45 | .0162 | .0000 | -     | 3.4 | -     |
| - | 1893  | - | - | .01 | 6.86 | .0036 | .0022 | .47 | .0179 | .0000 | .0643 | 3.4 | .0020 |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

† June to December.

‡ January to May.

§ July.

NOTE to analyses of 1893; Odor of No. 9930 none, becoming distinctly aromatic after standing one day; of No. 10100, distinctly aromatic; of No. 10171, very faintly vegetable; of Nos. 10323 to 10652, inclusive, unpleasant or disagreeable; of all other samples, none. The odor in nearly every case disappeared on heating. — The samples were collected either from a faucet at the pumping station while pumping, or from the filter-basin. The November and December samples were collected after the covering of the filter-basin had been completed.



## WALTHAM.

*Microscopical Examination of Water from the Well and Filler-Basin of the Waltham Water Works.*

[Number of organisms per cubic centimeter.]

|                                 | 1893. |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|---------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                 | Jan.  | Jan.  | Feb.  | Feb.  | Mar.  | Mar.  | Apr.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of exami-<br>nation, . . .  | 11    | 26    | 14    | 28    | 14    | 28    | 13    | 27    | 16    | 14    | 15    | 16    | 14    | 10    | 14    | 13    |
| Number of<br>sample, . . .      | 9863  | 9930  | 10006 | 10046 | 10109 | 10171 | 10236 | 10323 | 10391 | 10514 | 10652 | 10805 | 11020 | 11161 | 11331 | 11474 |
| PLANTS.                         |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .               | 25    | 2,928 | 6     | 16    | 21    | 1     | 21    | 23    | 15    | 11    | 0     | 0     | 4     | 2     | 0     | 0     |
| Asterionella, . .               | 20    | 2,506 | 0     | 0     | 0     | 0     | 0     | 5     | 4     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Fragilaria, . . .               | 0     | 34    | 0     | 0     | 3     | pr.   | 7     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Melosira, . . .                 | 0     | 0     | 0     | 8     | 7     | 0     | 7     | 2     | 9     | 9     | 0     | 0     | 3     | 2     | 0     | 0     |
| Meridion, . . .                 | 2     | 0     | 0     | pr.   | 4     | 1     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Navicula, . . .                 | 1     | 0     | 1     | 2     | 1     | 0     | 2     | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     |
| Synedra, . . .                  | 1     | 240   | 3     | 6     | 6     | 0     | 4     | 16    | 2     | 1     | 0     | 0     | 1     | 0     | 0     | 0     |
| Tabellaria, . .                 | 1     | 148   | 2     | pr.   | pr.   | pr.   | pr.   | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Cyanophyceæ, Chroococcus, . . . |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Algae, . . .                    | 1     | pr.   | 4     | pr.   | 4     | pr.   | 1     | 0     | 22    | 0     | 0     | 1     | 0     | 0     | 0     | 0     |
| Pandorina, . .                  | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 21    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Scenedesmus, .                  | 1     | pr.   | 4     | pr.   | 4     | pr.   | 1     | 0     | 1     | 0     | 0     | 1     | 0     | 0     | 0     | 0     |
| ANIMALS.                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . .                  | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 234   | 0     | 1     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon, . .                  | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 51    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, . .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 180   | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Peridinium, . .                 | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 0     |
| Miscellaneous, Zoöglæa, . .     | 0     | 28    | 0     | 0     | 1     | 12    | 0     | 0     | 6     | 1     | 0     | 1     | 0     | 13    | 0     | 0     |
| TOTAL, . . .                    | 26    | 2,904 | 10    | 16    | 27    | 13    | 22    | 23    | 277   | 12    | 1     | 2     | 4     | 15    | 0     | 0     |

## WALTHAM.

*Chemical Examination of Water from the Distributing Reservoir of the Waltham Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                   |        | Residue on Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|---------------------|-------------------|--------|-------------------------|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.          | Sediment.         | Color. |                         | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1893.</b>        |                     |                   |        |                         |          |                  |           |             |           |                  |           |       |
| 9862    | Jan. 10             | Distinct.           | Cons.             | .02    | 6.70                    | .0000    | .0082            | .48       | .0100       | .0001     | .0800            | 3.5       | .0000 |
| 9929    | Jan. 24             | None.               | None.             | .00    | 7.05                    | .0054    | .0024            | .52       | .0180       | .0001     | .0474            | 3.5       | .0020 |
| 10005   | Feb. 13             | None.               | Cons.,<br>dark.   | .00    | 6.45                    | .0026    | .0056            | .51       | .0250       | .0000     | .0803            | 3.2       | .0000 |
| 10047   | Feb. 28             | None.               | Cons.,<br>dark.   | .03    | 6.55                    | .0018    | .0032            | .49       | .0070       | .0000     | .0936            | 3.1       | .0025 |
| 10110   | Mar. 13             | Slight.             | Cons.             | .03    | 6.60                    | .0000    | .0046            | .54       | .0200       | .0000     | .1021            | 3.2       | .0020 |
| 10172   | Mar. 27             | Decided.            | Cons.,<br>dark.   | .03    | 6.90                    | .0000    | .0092            | .41       | .0100       | .0001     | .1168            | 2.9       | .0050 |
| 10237   | Apr. 11             | Distinct.           | Cons.,<br>white.  | .04    | 6.70                    | .0000    | .0124            | .44       | .0220       | .0000     | .1022            | 2.7       | .0025 |
| 10322   | Apr. 26             | Slight.             | Cons.             | .02    | 5.50                    | .0002    | .0106            | .43       | .0070       | .0000     | .1131            | 2.9       | .0000 |
| 10390   | May 15              | Distinct.           | Cons.             | .05    | 6.65                    | .0000    | .0136            | .42       | .0150       | .0000     | .1277            | 2.6       | .0000 |
| 10515   | June 13             | Slight.             | Slight.           | .08    | 7.20                    | .0000    | .0098            | .51       | .0150       | .0002     | .1072            | 3.0       | .0000 |
| 10651   | July 12             | Distinct,<br>green. | Slight,<br>green. | .05    | 6.70                    | .0012    | .0078            | .46       | .0150       | .0000     | .0730            | 3.2       | .0070 |
| 10806   | Aug. 15             | Distinct,<br>green. | Slight,<br>green. | .01    | 6.60                    | .0000    | .0044            | .44       | .0070       | .0001     | .0671            | 3.0       | .0025 |
| 11021   | Sept. 13            | Slight.             | Slight.           | .03    | 6.75                    | .0000    | .0066            | .48       | .0180       | .0001     | .0936            | 3.4       | .0000 |
| 11160   | Oct. 10             | Slight.             | Cons.,<br>white.  | .05    | 6.55                    | .0000    | .0078            | .50       | .0000       | .0001     | .1001            | 3.5       | .0020 |
| 11330   | Nov. 14             | Slight.             | Cons.,<br>white.  | .03    | 6.90                    | .0000    | .0064            | .45       | .0110       | .0001     | .1909            | 3.1       | .0020 |
| 11475   | Dec. 12             | Distinct,<br>green. | Slight.           | .03    | 6.70                    | .0000    | .0048            | .48       | .0120       | .0001     | .1120            | 3.2       | .0020 |
| Av.*    | .....               | .....               | .....             | .04    | 6.72                    | .0006    | .0074            | .47       | .0127       | .0001     | .1033            | 3.1       | .0019 |

*Averages of Analyses of Previous Years.*

|   |       |   |   |     |      |       |       |     |       |       |       |     |       |
|---|-------|---|---|-----|------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1887† | - | - | .00 | 6.66 | .0007 | .0061 | .46 | .0197 | -     | -     | -   | -     |
| - | 1888  | - | - | .00 | 6.45 | .0003 | .0075 | .46 | .0248 | .0003 | -     | -   | -     |
| - | 1889‡ | - | - | .00 | 6.21 | .0003 | .0078 | .47 | .0280 | .0003 | -     | -   | -     |
| - | 1890§ | - | - | .00 | -    | .0000 | .0124 | .47 | .0280 | .0001 | -     | -   | -     |
| - | 1891  | - | - | .00 | 6.25 | .0000 | .0044 | .40 | .0200 | .0000 | -     | 3.0 | -     |
| - | 1892  | - | - | .01 | 6.28 | .0006 | .0082 | .44 | .0119 | .0001 | -     | 3.0 | -     |
| - | 1893  | - | - | .04 | 6.72 | .0006 | .0074 | .47 | .0127 | .0001 | .1033 | 3.1 | .0019 |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

† June to December.

‡ January to May.

§ February.

|| May.

NOTE to analyses of 1893; Odor, generally faintly aromatic or unpleasant or none; on heating, the odor is stronger and occasionally disagreeable or fishy. — The samples were collected from the reservoir at the gate-house, with the exception of the last two, which were collected from the reservoir at the side opposite the gate-house.

## WALTHAM.

*Microscopical Examination of Water from the Distributing Reservoir of the Waltham Water Works.*

[Number of organisms per cubic centimeter.]

|                             | 1893. |      |       |       |       |       |        |        |
|-----------------------------|-------|------|-------|-------|-------|-------|--------|--------|
|                             | Jan.  | Jan. | Feb.  | Feb.  | Mar.  | Mar.  | Apr.   | Apr.   |
| Day of examination, . . .   | 11    | 26   | 14    | 28    | 14    | 28    | 13     | 27     |
| Number of sample, . . .     | 9862  | 9929 | 10005 | 10047 | 10110 | 10172 | 10237  | 10322  |
| <b>PLANTS.</b>              |       |      |       |       |       |       |        |        |
| Diatomaceæ, . . .           | 3,384 | pr.  | 299   | 194   | 4,287 | 5,998 | 18,944 | 13,700 |
| Asterionella, . . .         | 2,920 | 0    | 246   | 168   | 3,916 | 5,360 | 9,544  | 5,560  |
| Cyclotella, . . .           | 52    | 0    | 3     | 7     | 0     | 0     | 0      | 0      |
| Fragilaria, . . .           | 0     | 0    | 15    | 0     | 0     | 0     | 0      | 0      |
| Melosira, . . .             | 0     | 0    | 2     | 0     | 10    | 0     | 0      | 0      |
| Synedra, . . .              | 88    | pr.  | 11    | 18    | 336   | 636   | 9,400  | 8,140  |
| Tabellaria, . . .           | 304   | 0    | 22    | 1     | 5     | 0     | 0      | 0      |
| Algae, . . .                | 149   | pr.  | 7     | 7     | 7     | 0     | 9      | 0      |
| Chlorococcus, . . .         | 0     | 0    | 0     | 2     | 0     | 0     | 1      | 0      |
| Protooccus, . . .           | 148   | 0    | 0     | 0     | 2     | 0     | 0      | 0      |
| Raphidium, . . .            | 0     | 0    | 0     | 0     | 0     | 0     | 0      | 0      |
| Scenedesmus, . . .          | 1     | pr.  | 7     | 5     | 5     | 0     | 8      | 0      |
| Fungi, Crenothrix, . . .    | 0     | 0    | 23    | 12    | 0     | 0     | 0      | 0      |
| <b>ANIMALS.</b>             |       |      |       |       |       |       |        |        |
| Rhizopoda, Actinophrys, .   | 0     | 0    | 0     | 0     | 0     | 0     | 0      | 0      |
| Infusoria, . . .            | 5     | 0    | pr.   | 0     | pr.   | 0     | 1      | 48     |
| Dinobryon, . . .            | 5     | 0    | 0     | 0     | 0     | 0     | 0      | 47     |
| Dinobryon cases, . . .      | 0     | 0    | 0     | 0     | pr.   | 0     | 0      | 0      |
| Encysted protozoa, . . .    | 0     | 0    | 0     | 0     | 0     | 0     | 0      | 0      |
| Monas, . . .                | 0     | 0    | 0     | 0     | 0     | 0     | 0      | 0      |
| Peridinium, . . .           | 0     | 0    | pr.   | 0     | pr.   | 0     | 1      | 1      |
| Uvella, . . .               | 0     | 0    | 0     | 0     | 0     | 0     | 0      | 0      |
| Vermes, Rotatorian ova, . . | 0     | 0    | 0     | 0     | pr.   | 0     | 0      | 1      |
| Miscellaneous, Zoöglæa, . . | 0     | 0    | 12    | 7     | 0     | 44    | 0      | 3      |
| TOTAL, . . .                | 3,518 | pr.  | 341   | 220   | 4,274 | 6,040 | 18,954 | 13,752 |

## WATER SUPPLY OF WARE.

The works for collecting water for this town were enlarged in the latter part of 1893 by sinking twelve tubular wells in the valley of Muddy Brook, about 500 feet north of the large well, which was previously the only source of supply for the town; and by constructing a well nine feet in diameter and six feet in depth at the

## WALTHAM.

*Microscopical Examination of Water from the Distributing Reservoir of the Waltham Water Works—Concluded.*

[Number of organisms per cubic centimeter.]

|                             | 1893.  |       |       |       |       |       |        |       |
|-----------------------------|--------|-------|-------|-------|-------|-------|--------|-------|
|                             | May.   | June. | July. | Aug.  | Sept. | Oct.  | Nov.   | Dec.  |
| Day of examination, . . .   | 16     | 14    | 15    | 16    | 14    | 10    | 14     | 13    |
| Number of sample, . . .     | 10390  | 10515 | 10651 | 10806 | 11021 | 11160 | 11330  | 11475 |
| <b>PLANTS.</b>              |        |       |       |       |       |       |        |       |
| Diatomaceæ, . . . .         | 13,460 | 231   | 1,100 | 5,400 | 1,140 | 888   | 14,838 | 4,474 |
| Asterionella, . . . .       | 980    | 212   | 920   | 4,840 | 700   | 888   | 14,800 | 4,400 |
| Cyclotella, . . . .         | 0      | 6     | Pr.   | 0     | 0     | 0     | 0      | 0     |
| Fragilaria, . . . .         | 0      | 0     | 0     | 0     | 0     | 0     | 0      | 0     |
| Melosira, . . . .           | 0      | 2     | 0     | 0     | 0     | 0     | 12     | 4     |
| Synedra, . . . .            | 12,480 | 8     | 180   | 560   | 440   | 0     | 0      | 2     |
| Tabellaria, . . . .         | 0      | 3     | 0     | 0     | 0     | 0     | 26     | 68    |
| Algæ, . . . .               | 2      | 1     | 1     | 2     | 180   | 4     | 22     | 0     |
| Chlorococcus, . . . .       | 0      | 0     | 0     | 0     | 0     | 4     | 2      | 0     |
| Protococcus, . . . .        | 0      | 0     | 0     | 0     | 0     | 0     | 20     | 0     |
| Raphidium, . . . .          | 0      | 0     | 0     | 0     | 180   | 0     | 0      | 0     |
| Scenedesmus, . . . .        | 2      | 1     | 1     | 2     | 0     | 0     | 0      | 0     |
| Fungi, Crenothrix, . . . .  | 0      | 1     | 0     | 0     | 0     | 2     | 0      | 0     |
| <b>ANIMALS.</b>             |        |       |       |       |       |       |        |       |
| Rhizopoda, Actinophrys, . . | 3      | 0     | 0     | 0     | 0     | 0     | 0      | 0     |
| Infusoria, . . . .          | 7      | 333   | 4     | 32    | 23    | 181   | 32     | 340   |
| Dinobryon, . . . .          | 0      | 196   | 0     | 0     | 0     | 164   | 30     | 104   |
| Dinobryon caesa, . . . .    | 0      | 136   | 2     | 0     | 18    | 9     | 0      | 236   |
| Encysted protozoa, . . . .  | 7      | 0     | 0     | 0     | 0     | 0     | 0      | 0     |
| Monas, . . . .              | 0      | 1     | 0     | 0     | 1     | 0     | 2      | 0     |
| Peridinium, . . . .         | 0      | 0     | 2     | 32    | 4     | 0     | 0      | 0     |
| Uvella, . . . .             | 0      | 0     | 0     | 0     | 0     | 8     | 0      | 0     |
| Vermes, Rotatorian ova, . . | 0      | 0     | 0     | 2     | 0     | 0     | 0      | 0     |
| Miscellaneous, Zoöglæa, . . | 0      | 5     | 70    | 28    | 0     | 32    | 4      | 0     |
| TOTAL, . . . .              | 13,472 | 571   | 1,175 | 5,464 | 1,343 | 1,107 | 14,896 | 4,814 |

site of a large spring located near the tubular wells. The tubular wells are located within an area approximately 150 feet in length and somewhat less than 100 feet in width. The depth of the wells varies from twenty-eight to thirty-nine feet and averages thirty-four feet. Water from the wells and spring flows by gravity through a twelve-inch pipe to the main well.

**WARE.***Chemical Examination of Water from the Well of the Ware Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albu- minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 9998    | 1893.<br>Feb. 13    | None.       | None.     | 0.0    | 9.55                    | .0004    | .0022         | .96       | .3500       | .0000     | .0637            | 3.5       | .0000 |
| 10817   | Aug. 16             | None.       | None.     | 0.0    | 12.60                   | .0000    | .0008         | 1.11      | .6000       | .0000     | .0237            | 3.9       | .0070 |

*Averages of Analyses of Previous Years.*

|   |       |   |   |     |       |       |       |      |       |       |       |     |       |
|---|-------|---|---|-----|-------|-------|-------|------|-------|-------|-------|-----|-------|
| - | 1887* | - | - | 0.0 | 7.05  | .0001 | .0011 | 0.50 | .2663 | -     | -     | -   | -     |
| - | 1888  | - | - | 0.0 | 7.58  | .0000 | .0011 | 1.36 | .3262 | .0002 | -     | -   | -     |
| - | 1889† | - | - | 0.0 | 8.14  | .0001 | .0013 | 0.89 | .3111 | .0000 | -     | -   | -     |
| - | 1890‡ | - | - | 0.0 | -     | .0002 | .0014 | 0.95 | .3400 | .0000 | -     | -   | -     |
| - | 1891§ | - | - | 0.0 | 11.70 | .0000 | .0000 | 1.44 | .7000 | .0000 | -     | 3.9 | -     |
| - | 1892  | - | - | 0.0 | 10.53 | .0000 | .0008 | 1.15 | .5666 | .0000 | -     | 3.8 | -     |
| - | 1893  | - | - | 0.0 | 11.08 | .0002 | .0015 | 1.04 | .4750 | .0000 | .0447 | 3.7 | .0035 |

\* June to November.

† January to June.

‡ February.

§ November.

|| February, July and December.

NOTE to analyses of 1893; Odor, none. — The samples were collected from a faucet at the pumping station while pumping.

*Microscopical Examination.*

No. 9998. No organisms.

No. 10817. Miscellaneous, *Zoëglæa*, 1.*Chemical Examination of Water from the Spring connected with the Ware Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|----------------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.      | Color. |                         | Free.    | Albu- minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 10866   | 1893.<br>July 17    | None.       | Slight, sandy. | 0.0    | 4.00                    | .0004    | .0018         | .18       | .0450       | .0000     | .0390            | 1.3       | .0000 |

Odor, none. — The sample was collected from the spring, which has since been connected with the main well.

*Microscopical Examination.*Infusoria, *Peridinium*, 1.

## WATERTOWN AND BELMONT.

WATER SUPPLY OF WATERTOWN AND BELMONT—WATERTOWN  
WATER SUPPLY COMPANY.

The Watertown Water Supply Company made extended investigations in 1893 with reference to obtaining an additional supply of water from the ground in the vicinity of its pumping station and examined other sources. The company also made an application to the State Board of Health for its advice relative to the improvement of its supply, and many of the analyses given in the following tables were made during the investigations of the Board, but at the end of the year the matter was still under consideration.

The investigations showed that the water collected by the original filter-gallery and by a system of tubular wells northwesterly from the pumping station was nearly the same in character as during the earlier years of the operation of the works, but water collected from the ground in an easterly direction from the pumping station has to a greater or less degree the usual characteristics of a water containing iron. The most successful results were obtained from some six-inch wells located about 950 feet southeast of the pumping station, and about forty feet from the river. A temporary pump was connected with these wells in the summer of 1893, and during the summer and autumn a material addition to the water supply was obtained from this source. The last three analyses in the table on page 314 are of samples of water from these wells. It is probable that most of the water which they supplied came by filtration from the river, and although it contained iron and manganese and did not show the high degree of chemical purification which water attains when it filters a sufficient distance through the ground under favorable circumstances, it was rendered very nearly pure, bacterially, by the filtration.

The table on page 315 contains the analyses of water from two deep tubular wells, one located near the pumping station, and the other in the centre of the main village of Watertown. Neither of these deep wells furnished any large quantity of water nor was the quality of the water satisfactory, and no part of the water supply of the town is now taken from them.

**WATERTOWN AND BELMONT.***Chemical Examination of Water from a Faucet in the Pumping Station of the Watertown Water Supply Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                  |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|------------------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment.        | Color. |                         | Free.    | Albu- minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1893.</b>        |                  |                  |        |                         |          |               |           |             |           |                  |           |       |
| 9990    | Feb. 8              | V. slight.       | V. slight.       | .02    | 7.70                    | .0012    | .0082         | .67       | .0700       | .0001     | .1168            | 3.5       | .0130 |
| 10105   | Mar. 8              | None.            | None.            | .05    | 8.05                    | .0006    | .0010         | .66       | .0800       | .0000     | .0360            | 3.8       | .0020 |
| 10245   | Apr. 11             | V. slight.       | V. slight.       | .05    | 6.45                    | .0016    | .0126         | .49       | .0650       | .0000     | .1241            | 2.5       | .0045 |
| 10417   | May 17              | None.            | None.            | .02    | 8.05                    | .0000    | .0054         | .55       | .0950       | .0000     | .0730            | 2.7       | .0060 |
| 10502   | June 8              | None.            | None.            | .00    | 7.75                    | .0000    | .0030         | .67       | .0900       | .0000     | .0402            | 3.6       | .0050 |
| 10620   | July 7              | Slight, milky.   | Slight, rusty.   | .25    | 8.60                    | .0086    | .0068         | .69       | .0400       | .0001     | .1241            | 3.4       | .0330 |
| 10741   | Aug. 8              | V. slight.       | V. slight.       | .20    | 7.70                    | .0098    | .0046         | .64       | .0250       | .0001     | .1184            | 4.3       | .0240 |
| 11040   | Sept. 18            | Distinct, milky. | Slight, rusty.   | .65    | 9.00                    | .0186    | .0088         | .72       | .0100       | .0002     | .2418            | 3.7       | .1050 |
| 11155   | Oct. 9              | Distinct, milky. | Slight, fibrous. | .50    | 8.70                    | .0160    | .0074         | .76       | .0950       | .0000     | .2040            | 3.6       | .0720 |
| 11307   | Nov. 8              | Distinct.        | Slight.          | .30    | 7.80                    | .0076    | .0054         | .76       | .0300       | .0002     | .1680            | 3.5       | .0425 |
| 11466   | Dec. 6              | None.            | V. slight.       | .10    | 7.60                    | .0058    | .0038         | .72       | .0280       | .0001     | .1560            | 3.6       | .0390 |
| Av...   | .....               | .....            | .....            | .19    | 7.95                    | .0063    | .0061         | .66       | .0489       | .0001     | .1275            | 3.5       | .0315 |

*Averages of Analyses of Previous Years.*

|   |       |   |   |     |      |       |       |     |       |       |       |     |       |
|---|-------|---|---|-----|------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1887* | - | - | .00 | 7.09 | .0005 | .0034 | .65 | .0300 | -     | -     | -   | -     |
| - | 1888  | - | - | .00 | 7.22 | .0000 | .0040 | .63 | .0617 | .0000 | -     | -   | -     |
| - | 1889† | - | - | .00 | 6.45 | .0000 | .0027 | .64 | .0642 | .0000 | -     | -   | -     |
| - | 1890‡ | - | - | .00 | 7.40 | .0014 | .0042 | .69 | .0450 | .0000 | -     | 3.9 | -     |
| - | 1892§ | - | - | .07 | 7.90 | .0041 | .0046 | .66 | .0370 | .0001 | -     | 4.0 | .0396 |
| - | 1893  | - | - | .19 | 7.95 | .0063 | .0061 | .66 | .0489 | .0001 | .1275 | 3.5 | .0315 |

\* June to December.

† January to May.

‡ August.

§ September to December.

NOTE to analyses of 1893; Odor, generally none, occasionally mouldy and unpleasant. — The samples were collected from a faucet at the pumping station while pumping.

In the above table the samples with the higher amounts of iron became turbid and colored by the precipitation of the iron by oxidation on exposure to the air.

## WATERTOWN AND BELMONT.

*Microscopical Examination of Water from a Faucet in the Pumping Station of the Watertown Water Supply Company.*

[Number of organisms per cubic centimeter.]

|                               | 1893. |       |       |       |       |       |       |       |       |       |       |  |
|-------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--|
|                               | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |  |
| Day of examination, . . .     | 11    | 10    | 13    | 19    | 9     | 11    | 8     | 19    | 10    | 10    | 8     |  |
| Number of sample, . . .       | 9990  | 10105 | 10215 | 10417 | 10502 | 10620 | 10741 | 11040 | 11155 | 11307 | 11400 |  |
| PLANTS.                       |       |       |       |       |       |       |       |       |       |       |       |  |
| Diatomaceæ, . . .             | 0     | 0     | 1     | 4     | 0     | 0     | 0     | 5     | 0     | 28    | 0     |  |
| Asterionella, . . .           | 0     | 0     | 0     | 4     | 0     | 0     | 0     | 4     | 0     | 0     | 0     |  |
| Synedra, . . .                | 0     | 0     | 1     | pr.   | 0     | 0     | 0     | 1     | 0     | 20    | 0     |  |
| Tabellaria, . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 8     | 0     |  |
| Cyanophyceæ, . . .            | 0     | 0     | 0     | 0     | 6     | 0     | 16    | 0     | 0     | 0     | 0     |  |
| Anabæna, . . .                | 0     | 0     | 0     | 0     | 6     | 0     | 0     | 0     | 0     | 0     | 0     |  |
| Oscillaria, . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 16    | 0     | 0     | 0     | 0     |  |
| Fungi, Crenothrix, . . .      | 12    | 0     | pr.   | 0     | 0     | 680   | 64    | 520   | 61    | 64    | 7     |  |
| Miscellaneous, Zoögloæ, . . . | 28    | 0     | 0     | 0     | 0     | 76    | 28    | 240   | 72    | 96    | pr.   |  |
| TOTAL, . . .                  | 40    | 0     | 1     | 4     | 6     | 756   | 108   | 765   | 133   | 188   | 7     |  |

*Chemical Examination of Water from a Faucet in Watertown, supplied from the Works of the Watertown Water Supply Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |            |        | Residue on Evaporation. | AMMONIA. |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------------|------------|--------|-------------------------|----------|-----------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.        | Sediment.  | Color. |                         | Free.    | Alu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 1893.   |                     |                   |            |        |                         |          |                 |           |             |           |                  |           |       |
| 9913    | Jan. 23             | None.             | None.      | 0.02   | 10.20                   | .0000    | .0030           | .68       | .0900       | .0001     | .0603            | 4.7       | .0100 |
| 10040   | Feb. 20             | None.             | V. slight. | 0.08   | 6.80                    | .0000    | .0110           | .52       | .0800       | .0001     | .2197            | 3.4       | .0130 |
| 10142   | Mar. 20             | Distinct, milky.  | V. slight. | 0.10   | 6.75                    | .0000    | .0046           | .51       | .0550       | .0000     | .1008            | 2.9       | .0260 |
| 10260   | Apr. 18             | None.             | None.      | 0.03   | 6.95                    | .0000    | .0014           | .54       | .0600       | .0000     | .1095            | 3.0       | .0055 |
| 10409   | May 17              | None.             | None.      | 0.05   | 7.15                    | .0010    | .0058           | .55       | .0450       | .0002     | .0657            | 3.0       | .0075 |
| 10513   | June 13             | None.             | None.      | 0.05   | 8.45                    | .0000    | .0082           | .57       | .0120       | .0001     | .0703            | 3.4       | .0050 |
| 10663   | July 13             | V. slight.        | None.      | 0.03   | 8.30                    | .0004    | .0042           | .59       | .0500       | .0000     | .1022            | 3.8       | .0080 |
| 10804   | Aug. 15             | Slight.           | V. slight. | 0.13   | 8.00                    | .0000    | .0044           | .66       | .0110       | .0000     | .1280            | 3.9       | .0200 |
| 11035   | Sept. 15            | Slight, milky.    | V. slight. | 0.20   | 8.70                    | .0118    | .0066           | .69       | .0090       | .0005     | .1794            | 3.9       | .0500 |
| 11219   | Oct. 17             | V. slight, milky. | None.      | 0.15   | 8.70                    | .0002    | .0062           | .68       | .0300       | .0000     | .1863            | 4.2       | .0220 |
| 11365   | Nov. 21             | V. slight, milky. | None.      | 0.10   | 8.30                    | .0010    | .0044           | .68       | .0270       | .0000     | .2100            | 4.3       | .0160 |
| 11534   | Dec. 19             | V. slight, milky. | None.      | 0.05   | 8.40                    | .0000    | .0026           | .66       | .0420       | .0000     | .1458            | 4.2       | .0150 |
| Av..    | .....               | .....             | .....      | 0.09   | 8.06                    | .0012    | .0052           | .61       | .0426       | .0001     | .1322            | 3.7       | .0165 |

Odor of the first sample, none, becoming distinctly unpleasant on heating; of the third sample, distinctly earthy, disappearing on heating; of No. 10804, none, becoming very faintly vegetable on heating; of the remaining samples, none. — The samples were collected from a faucet in a house in the easterly part of Watertown.



**WATERTOWN AND BELMONT.***Microscopical Examination of Water from a Faucet in Watertown, supplied from the Works of the Watertown Water Supply Company.*

[Number of organisms per cubic centimeter.]

|                                   | 1893.    |           |            |          |          |          |          |          |            |          |          |          |
|-----------------------------------|----------|-----------|------------|----------|----------|----------|----------|----------|------------|----------|----------|----------|
|                                   | Jan.     | Feb.      | Mar.       | Apr.     | May.     | June     | July.    | Aug.     | Sept.      | Oct.     | Nov.     | Dec.     |
| Day of examination, .             | 24       | 24        | 21         | 19       | 18       | 14       | 15       | 16       | 16         | 20       | 23       | 23       |
| Number of sample, .               | 9913     | 10040     | 10142      | 10200    | 10409    | 10513    | 10663    | 10804    | 11035      | 11219    | 11365    | 11334    |
| <b>PLANTS.</b>                    |          |           |            |          |          |          |          |          |            |          |          |          |
| Cyanophyceæ, Rivularia, . . . . . | 0        | 0         | 0          | 0        | 0        | 4        | 0        | 3        | 0          | 1        | 0        | 0        |
| Fungi, Crenothrix, .              | 0        | 0         | 0          | 0        | 0        | 0        | 0        | 0        | 92         | 0        | 1        | 0        |
| <b>ANIMALS.</b>                   |          |           |            |          |          |          |          |          |            |          |          |          |
| Infusoria, Peridinium, .          | 0        | 0         | 0          | 1        | 0        | 0        | 0        | 0        | 0          | 0        | 1        | 0        |
| Miscellaneous, Zoöglæa, .         | 0        | 10        | 530        | 0        | 0        | 1        | 0        | 0        | 56         | pr.      | 0        | 0        |
| <b>TOTAL, . . . . .</b>           | <b>0</b> | <b>10</b> | <b>530</b> | <b>1</b> | <b>0</b> | <b>5</b> | <b>0</b> | <b>3</b> | <b>148</b> | <b>1</b> | <b>2</b> | <b>0</b> |

*Chemical Examination of Water from Tubular Test Wells in the Vicinity of the Pumping Station of the Watertown Water Supply Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.    |                 |        | Residue on Evaporation. | AMMONIA. |              | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron.  |
|---------|---------------------|----------------|-----------------|--------|-------------------------|----------|--------------|-----------|-------------|-----------|------------------|-----------|--------|
|         |                     | Turbidity.     | Sediment.       | Color. |                         | Free.    | Alb- minold. |           | Nitrates.   | Nitrites. |                  |           |        |
|         |                     |                |                 |        |                         |          |              |           |             |           |                  |           |        |
|         | 1893.               |                |                 |        |                         |          |              |           |             |           |                  |           |        |
| 9935    | Jan. 25             | None.          | None.           | 0.00   | 6.80                    | .0000    | .0018        | .62       | .0650       | .0000     | .0292            | 2.6       | .0050  |
| 10418   | May 16              | Slight, milky. | Slight, rusty.  | 0.60   | 9.10                    | .0240    | .0104        | .58       | .0030       | .0003     | .2993            | 3.8       | .0760* |
| 10550   | June 21             | None.          | Slight, earthy. | 0.25   | 7.30                    | .0220    | .0108        | .56       | .0000       | .0000     | .3041            | 3.6       | .0100  |
| 10619   | July 8              | Slight, milky. | Slight, white.  | 0.25   | 8.30                    | .0196    | .0076        | .55       | .0000       | .0000     | .2336            | 4.2       | .0180  |
| 10667   | July 17             | None.          | None.           | 0.20   | 8.80                    | .0230    | .0084        | .56       | .0000       | .0001     | .3120            | 3.9       | .0320  |
| 11237   | Oct. 23             | V. slight.     | None.           | 0.55   | 8.95                    | .0282    | .0162        | .68       | .0000       | .0000     | .3192            | 3.9       | .0110  |

\* This sample contained also 0.1760 part manganese.

Odor of the first three samples, none; of the last three, mouldy or unpleasant; on heating, the odor of the second sample was distinctly vegetable, and of the last two, faintly vegetable. — The first sample was collected from a group of tubular wells located a short distance northwest of the pumping station; the second and third, from a flowing well two inches in diameter, located about one thousand feet southeasterly from the pumping station and about seventy-five feet from Charles River; the last three, from six-inch tubular wells, located about nine hundred and fifty feet southeast of the pumping station and about forty feet from the river. Water was pumped from these six-inch wells into the filter-gallery in the summer and autumn of 1893.

## WATERTOWN AND BELMONT.

*Microscopical Examination.*

No. 10418. Diatomaceæ, *Melosira*, 3; *Tabellaria*, 2. Fungi, *Crenothrix*, 34. Miscellaneous, *Zoëglæa*, 24. Total, 63.

No. 10667. Fungi, *Crenothrix*, 10. Miscellaneous, *Zoëglæa*, 2. Total, 12.

No organisms were found in the remaining samples.

*Bacterial Examination.*

Three samples of water collected on June 30 from the two-inch flowing well from which Nos. 10418 and 10550 were collected, contained an average of five bacteria per cubic centimeter, the highest number found being seven and the lowest two.

Three samples of water collected on July 17 from the six-inch tubular wells contained an average of four bacteria per cubic centimeter.

These wells were examined again on October 23, two samples being collected, each of which contained four bacteria per cubic centimeter.

*Chemical Examination of Water from Deep Tubular Wells in Watertown.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                 |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|-----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment.       | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 10252*  | 1893.<br>Apr. 11    |                  |                 |        |                         |          |             |           |             |           |                  |           |       |
|         |                     | Decided, clayey. | Heavy, clayey.  | 0.0    | 44.50                   | .0020    | .0012       | 1.34      | .0000       | .0000     | .0255            | 17.9      | .0020 |
| 10530   | June 19             | Slight, clayey.  | Slight, earthy. | 0.0    | 22.40                   | .0018    | .0000       | 1.65      | .0030       | .0000     | .0100            | 6.3       | .0000 |

\* All determinations of this sample were made on the filtered water.

Odor of the first sample, faintly earthy; of the last, none. — The first sample was collected from a tubular well eight inches in diameter and about 250 feet in depth, located about fifty feet south of the pumping station of the Watertown Water Supply Company; the last, from a deep tubular well located near the centre of the main village of Watertown and near the railroad station. It is said that 160,000 gallons of water were pumped from the latter well in the twenty-six hours previous to the collection of the sample.

*Microscopical Examination.*

No organisms.

## WATER SUPPLY OF WEBSTER.

*Description of Works.* — Population in 1890, 7,031. The works are owned by the town and water was introduced Jan. 1, 1894. The town had been supplied for many years previous to this time from works owned by H. L. Slater, the source of supply being Lake Chaubunagungamaug. The new source of supply is a well twenty-five feet in diameter and thirty feet in depth, located on the northwesterly side of the lake, about 200 feet from the shore. The wall of the well is made of stone, laid without mortar, for a height of three feet above the bottom, and above this level also of stone,

**SPRINGFIELD.**

*Microscopical Examination of Water from Ludlow Reservoir,  
Springfield.*

The number of organisms found in the samples of water collected from Ludlow reservoir in the months of January, February and June was insignificant. In March, April and May the samples contained respectively 3,850, 1,065 and 1,590 organisms per cubic centimeter, consisting almost wholly of Dinobryon or Dinobryon cases. The results of the microscopical examination of samples collected during the remainder of the year are given in the following table :—

*Microscopical Examination of Water from Ludlow Reservoir.*

[Number of organisms per cubic centimeter.]

[illegible]

## WESTBOROUGH.

## WATER SUPPLY OF WESTBOROUGH.

The advice of the State Board of Health to the town of Westborough, with reference to increasing the supply of filtered water from the Lower Sandra Basin by facilitating the filtration of water from the Upper Basin into it through the intervening ground may be found on page 63 of this volume.

## WATER SUPPLY OF WESTBOROUGH INSANE HOSPITAL, WESTBOROUGH.

*Chemical Examination of Water from the Tubular Wells at the Westborough Insane Hospital.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |            |        | Residue on Evaporation. | AMMONIA. |              | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|------------|--------|-------------------------|----------|--------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment.  | Color. |                         | Free.    | Alb.-minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 9936    | 1892.<br>Jan. 25    | Slight, milky.   | None.      | 0.42   | 11.15                   | .0846    | .0056        | .42       | .0030       | .0001     | .1131            | 5.8       | .1300 |
| 10162   | Mar. 27             | Distinct, milky. | None.      | 0.30   | 11.15                   | .0564    | .0068        | .41       | .0280       | .0001     | .0847            | 6.0       | .1100 |
| 10444   | May 24              | Slight, milky.   | V. slight. | 0.40   | 10.95                   | .0720    | .0050        | .37       | .0000       | .0000     | .1575            | 5.4       | .0675 |
| 10678   | July 18             | Slight, milky.   | V. slight. | 0.18   | 11.10                   | .0900    | .0050        | .40       | .0000       | .0001     | .1248            | 5.8       | .0780 |
| Av...   | .....               | .....            | .....      | 0.33   | 11.09                   | .0758    | .0056        | .40       | .0078       | .0001     | .1200            | 5.8       | .0964 |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |       |       |       |     |       |       |       |     |       |
|---|-------|---|---|------|-------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1887* | - | - | 0.03 | 11.29 | .0407 | .0033 | .42 | .0030 | -     | -     | -   | -     |
| - | 1888  | - | - | 0.06 | 11.27 | .0502 | .0051 | .42 | .0045 | .0000 | -     | -   | -     |
| - | 1889† | - | - | 0.16 | 11.41 | .0630 | .0049 | .43 | .0030 | .0000 | -     | -   | -     |
| - | 1891‡ | - | - | 0.50 | 11.80 | .0784 | .0109 | .43 | .0040 | .0000 | -     | 6.0 | -     |
| - | 1893  | - | - | 0.33 | 11.09 | .0758 | .0056 | .40 | .0078 | .0001 | .1200 | 5.8 | .0964 |

\* June to December.

† January to May.

‡ July, two samples.

NOTE to analyses of 1893; Odor of the first sample, none, becoming distinctly vegetable and grassy on heating; of the second sample, offensive, disappearing on heating; of the remaining samples, none. — The samples were collected from a faucet at the pumping station while pumping.

Iron in considerable amount is characteristic of the water of these wells. It oxidizes promptly on exposure to the air and precipitates, causing first a milky turbidity and then a rusty precipitate. Somewhat similar conditions exist in the water supplies of Reading, Bradford and other places.

*Microscopical Examination.*

The organisms found in these samples in 1893 were chiefly Zoöglas, the greatest number, 124, being present in January, and the smallest, 6, in May.

## WESTFIELD.

## WATER SUPPLY OF WESTFIELD.

*Chemical Examination of Water from the Storage Reservoir of the Westfield Water Works, on Moose Meadow Brook, Montgomery.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1893.   |                     |             |           |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 10942   | Aug. 31             | Distinct.   | Slight.   | 0.75   | 3.00                    | 1.60              | .0000    | .0222       | .0174      | .0048      | .09       | .0000       | .0000     | 0.6083           | 0.2       |
| 11260   | Oct. 27             | Slight.     | Cons.     | 1.20   | 3.40                    | 1.50              | .0010    | .0220       | .0170      | .0050      | .16       | .0020       | .0000     | 1.0092           | 0.8       |

Iron, .0278. Odor of the first sample, faintly vegetable, becoming stronger on heating; of the last, distinctly earthy, becoming vegetable on heating. — The samples were collected from the reservoir.

*Microscopical Examination.*

No. 10942. Diatomaceæ, *Asterionella*, 1,920; *Cocconeis*, 40; *Cocconeis*, 1; *Cyclotella*, 2; *Diatoma*, 64; *Synedra*, 80. Cyanophyceæ, *Spores*, 1. Algeæ, *Chlorococcus*, 9; *Raphidium*, 4; *Staurastrum*, 2. Fungi, *Crenothrix*, 1. Rhizopoda, *Arcella*, 3; *Amphiglena*, 2. Infusoria, *Peridinium*, 24; *Trachelomonas*, 3. Vermeæ, *Anurea*, 2; *Monocerca*, 1; *Polyarthra*, 1. Miscellaneous, *Zoëglæa*, 84. Total, 2,244.

No. 11260. Diatomaceæ, *Asterionella*, 144; *Navicula*, 1; *Synedra*, 1; *Tabellaria*, 128. Algeæ, *Scenedesmus*, 1; *Staurastrum*, 1; *Zoëspores*, 1. Fungi, *Crenothrix*, 24. Infusoria, *Trachelomonas*, 5. Miscellaneous, *Zoëglæa*, 32. Total, 338.

*Chemical Examination of Water from the Distributing Reservoir of the Westfield Water Works, on Moose Meadow Brook, Montgomery.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1893.   |                     |             |            |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 10564   | June 24             | Slight.     | Slight.    | 0.35   | 2.75                    | 1.25              | .0014    | .0180       | .0154      | .0026      | .11       | .0030       | .0001     | .4661            | 0.3       |
| 10943   | Aug. 31             | Distinct.   | Slight.    | 0.90   | 3.45                    | 1.35              | .0000    | .0174       | .0144      | .0030      | .13       | .0000       | .0000     | .6438            | 0.6       |
| 11261   | Oct. 27             | Slight.     | V. slight. | 0.90   | 3.80                    | 1.65              | .0006    | .0142       | .0122      | .0020      | .23       | .0000       | .0000     | .9744            | 0.6       |
| Av.     | .....               | .....       | .....      | 0.72   | 3.33                    | 1.42              | .0007    | .0165       | .0140      | .0025      | .16       | .0010       | .0000     | .6948            | 0.5       |

Iron, .0098. Odor of the first sample, distinctly mouldy; of the second, distinctly vegetable and sweetish; of the last, faintly vegetable. — The samples were collected from the lower or distributing reservoir in Montgomery. Water flows from the storage to the distributing reservoir, a distance of a little more than two miles, in the open channel of the brook, falling more than 400 feet in its course from the storage reservoir. The lower reservoir has a drainage area of two and one-quarter square miles in addition to that of the storage reservoir.

## WESTFIELD.

*Microscopical Examination of Water from the Distributing Reservoir of the Westfield Water Works.*

[Number of organisms per cubic centimeter.]

|                                   | 1893.      |            |            |
|-----------------------------------|------------|------------|------------|
|                                   | June.      | September. | October.   |
| Day of examination, . . . . .     | 27         | 2          | 28         |
| Number of sample, . . . . .       | 10564      | 10943      | 11261      |
| <b>PLANTS.</b>                    |            |            |            |
| Diatomaceæ, . . . . .             | 182        | 9          | 5          |
| Asterionella, . . . . .           | 32         | 5          | 0          |
| Diatoma, . . . . .                | 8          | 0          | 0          |
| Epithemia, . . . . .              | 2          | 0          | 1          |
| Navicula, . . . . .               | pr.        | 2          | 2          |
| Planularia, . . . . .             | pr.        | 1          | 1          |
| Synedra, . . . . .                | 14         | 1          | 0          |
| Tabellaria, . . . . .             | 126        | 0          | 1          |
| Algæ, . . . . .                   | 2          | 19         | 3          |
| Arthrodesmus, . . . . .           | 0          | 2          | 0          |
| Chlorococcus, . . . . .           | 0          | 7          | 1          |
| Protococcus, . . . . .            | 0          | 10         | 0          |
| Staurostrum, . . . . .            | 0          | 0          | 2          |
| Zöospores, . . . . .              | 2          | 0          | 0          |
| Fungi, Crenothrix, . . . . .      | 20         | 64         | 112        |
| <b>ANIMALS.</b>                   |            |            |            |
| Infusoria, . . . . .              | 19         | 2          | 0          |
| Dinobryon cases, . . . . .        | 5          | 0          | 0          |
| Peridinium, . . . . .             | 14         | 2          | 0          |
| Trachelomonas, . . . . .          | 0          | 0          | 1          |
| Miscellaneous, Zoöglæa, . . . . . | 18         | 64         | 1          |
| <b>TOTAL, . . . . .</b>           | <b>241</b> | <b>158</b> | <b>121</b> |

**WESTFIELD.***Chemical Examination of Water from a Faucet in Westfield, supplied from the Westfield Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. |           |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. | Oxygen Consumed. | Hardness. |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 10041   | Feb. -*             | V. slight.  | V. slight. | 0.50   | 2.75                    | 0.75              | .0014    | .0120       | .0084      | .0036      | .12       | .0090       | .0000     | .4437            | 0.9       |
| 10334   | Apr. 29             | V. slight.  | Slight.    | 0.35   | 1.85                    | 1.00              | .0000    | .0114       | .0076      | .0038      | .08       | .0050       | .0001     | .3723            | 0.2       |
| 11561   | Dec. 29             | V. slight.  | Slight.    | 0.40   | 2.65                    | 0.90              | .0000    | .0082       | .0072      | .0010      | .13       | .0300       | .0000     | .3927            | 1.4       |
| Av.     | .....               | .....       | .....      | 0.42   | 2.42                    | 0.88              | .0005    | .0105       | .0077      | .0028      | .11       | .0147       | .0000     | .4029            | 0.8       |

\* Received in laboratory February 25.

Iron, .0088. Odor, faintly vegetable. — The samples were collected from a faucet in the town.

*Microscopical Examination of Water from a Faucet in Westfield, supplied from the Westfield Water Works.*

[Number of organisms per cubic centimeter.]

|                                   | 1893.     |       | 1894.    |
|-----------------------------------|-----------|-------|----------|
|                                   | February. | May.  | January. |
| Day of examination, . . . . .     | 28        | 2     | 1        |
| Number of sample, . . . . .       | 10041     | 10334 | 11561    |
| <b>PLANTS.</b>                    |           |       |          |
| Diatomaceæ, . . . . .             | 13        | 17    | 4        |
| Asterionella, . . . . .           | pr.       | 1     | 1        |
| Cyclotella, . . . . .             | 3         | pr.   | 0        |
| Diatoma, . . . . .                | 1         | pr.   | 0        |
| Eplihemia, . . . . .              | pr.       | 3     | 1        |
| Meridion, . . . . .               | 2         | 4     | pr.      |
| Navicula, . . . . .               | 3         | 2     | pr.      |
| Nitzschia, . . . . .              | 2         | 0     | 0        |
| Synedra, . . . . .                | 0         | 1     | 2        |
| Tabellaria, . . . . .             | 2         | 6     | pr.      |
| Algæ, Zoospores, . . . . .        | 4         | 18    | 0        |
| <b>ANIMALS.</b>                   |           |       |          |
| Infusoria, . . . . .              | 14        | 44    | 1        |
| Dinobryon casea, . . . . .        | 0         | 4     | 0        |
| Peridinium, . . . . .             | 14        | 40    | 1        |
| Miscellaneous, Zoöglæa, . . . . . | 88        | 5     | 0        |
| TOTAL, . . . . .                  | 119       | 84    | 5        |

## WEST SPRINGFIELD.

## WATER SUPPLY OF WEST SPRINGFIELD.

The town of West Springfield extended its works in 1893 with a view to supplying water to the village of Mittineague, which is situated at too great an elevation to be supplied with water from the existing works. The new source of supply is a well twenty-five feet in diameter and fourteen feet deep, located at the Craig Spring, a short distance below the storage reservoir. The well is supplied in part by the numerous springs in its vicinity, the water of which is collected by means of small pipes into a main pipe which carries it to a settling well and thence to the main well. Water is pumped from this well by means of a windmill to a tank at Mittineague. The advice of the State Board of Health to the town of West Springfield relative to an additional water supply for the town may be found on page 65.

*Chemical Examination of Water from Various Sources, collected during an Investigation for an Additional Water Supply for West Springfield.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |               |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |           | Chlorine. | NITROGEN AS |                  | Oxygen Consumed. |            |
|---------|---------------------|-------------|---------------|--------|-------------------------|-------------------|----------|-------------|------------|-----------|-----------|-------------|------------------|------------------|------------|
|         |                     | Turbidity.  | Sediment.     | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            | Nitrates. |           | Nitrites.   | Oxygen Consumed. | Hardness.        |            |
|         |                     |             |               |        |                         |                   |          | Total.      | Dissolved. |           |           |             |                  |                  | Suspended. |
| 1893.   |                     |             |               |        |                         |                   |          |             |            |           |           |             |                  |                  |            |
| 10403   | May 16              | V. slight.  | Slight.       | 0.12   | 5.60                    | 1.30              | .0002    | .0114       | .0100      | .0014     | .09       | .0120       | .0000            | .2518            | 3.2        |
| 10400   | May 16              | None.       | None.         | 0.00   | 5.80                    | -                 | .0000    | .0008       | -          | -         | .13       | .0380       | .0000            | .0328            | 3.5        |
| 10401   | May 16              | V. slight.  | Cons. sand.   | 0.04   | 3.45                    | 0.80              | .0000    | .0024       | .0018      | .0006     | .21       | .0800       | .0000            | .0766            | 1.8        |
| 10402   | May 16              | V. slight.  | V. slight.    | 0.04   | 8.10                    | 1.00              | .0000    | .0040       | .0032      | .0008     | .11       | .0000       | .0000            | .0949            | 5.7        |
| 10404   | May 16              | V. slight.  | Slight.       | 0.30   | 4.00                    | 1.55              | .0000    | .0096       | .0078      | .0018     | .10       | .0070       | .0001            | .3759            | 1.8        |
| 10443   | May 23              | V. slight.  | Slight, dark. | 0.00   | 5.10                    | -                 | .0000    | .0024       | -          | -         | .39       | .1800       | .0000            | .0600            | 1.6        |

Iron, .0041. Odor of the first and fourth samples, distinctly vegetable and grassy, becoming faintly vegetable on heating; of the second and third, none; of the last two, very faintly vegetable. — The first sample was collected from Bear Hole Brook, in the northwesterly part of West Springfield, near the Massasoit Spring, and about two miles below the outlet of Ashley Pond; the second, from the Massasoit Spring; the third, from Leonard Brook in Agawam, about half a mile above its mouth. This brook is a very small tributary of the Westfield River, and enters it from the south at the first bridge above its mouth. The fourth sample was collected from Lathrop Brook in West Springfield, a small tributary of Block Brook, entering it about a mile and a half from its mouth; the fifth sample from Hyde Brook in West Springfield, at the point where it is crossed by a road leading from Mittineague to Prospect Hill; and the last sample from the Craig Spring, which is now used to supply the village of Mittineague.



WEST SPRINGFIELD.

*Microscopical Examination of Water from Various Sources collected during an Investigation for an Additional Water Supply for West Springfield.*

[Number of organisms per cubic centimeter.]

|                                   | 1892. |       |       |       |       |       |
|-----------------------------------|-------|-------|-------|-------|-------|-------|
|                                   | May.  | May.  | May.  | May.  | May.  | May.  |
| Day of examination, . . . . .     | 18    | 18    | 18    | 18    | 18    | 25    |
| Number of sample, . . . . .       | 10403 | 10400 | 10401 | 10402 | 10404 | 10443 |
| PLANTS.                           |       |       |       |       |       |       |
| Diatomaceæ, . . . . .             | 24    | 2     | 12    | 3     | 5     | 21    |
| Asterionella, . . . . .           | 2     | 0     | 0     | 0     | 0     | 0     |
| Cocconeina, . . . . .             | 0     | 0     | 0     | 0     | 0     | 3     |
| Cyclotella, . . . . .             | 1     | 0     | 0     | 0     | 0     | 0     |
| Cymbella, . . . . .               | 2     | 0     | 0     | 0     | pr.   | 0     |
| Diatoma, . . . . .                | 0     | 0     | 1     | 1     | 1     | 14    |
| Fragilaria, . . . . .             | 1     | 0     | 0     | 0     | 0     | 0     |
| Melosira, . . . . .               | 0     | 1     | 0     | 0     | 1     | 0     |
| Meridion, . . . . .               | 8     | 0     | 2     | 0     | 1     | 0     |
| Navicula, . . . . .               | 0     | 0     | 3     | pr.   | 1     | 2     |
| Stauronella, . . . . .            | 0     | 0     | 0     | 0     | 0     | 2     |
| Synedra, . . . . .                | 16    | 1     | 6     | 2     | 1     | 0     |
| Tabellaria, . . . . .             | 4     | 0     | 0     | 0     | 0     | 0     |
| Algæ, Staurastrum, . . . . .      | 0     | 0     | 0     | 3     | pr.   | 0     |
| Fungi, . . . . .                  | 1     | 0     | 9     | 0     | 1     | 0     |
| Crenothrix, . . . . .             | 1     | 0     | 9     | 0     | 0     | 0     |
| Molds, . . . . .                  | 0     | 0     | 0     | 0     | 1     | 0     |
| Miscellaneous, Zoöglæa, . . . . . | 4     | 2     | 48    | 4     | 28    | 18    |
| TOTAL, . . . . .                  | 39    | 4     | 69    | 10    | 34    | 37    |

WATER SUPPLY OF WEYMOUTH.

*Chemical Examination of Water from Faucets in Weymouth, supplied from the Weymouth Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                 |        | RESIDUE ON EVAPORA-<br>TION. |                      | AMMONIA. |            |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. |           |
|---------|---------------------|-------------|-----------------|--------|------------------------------|----------------------|----------|------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.       | Color. | Total.                       | Loss on<br>Ignition. | Free.    | Albuminoid |            |                 |           | Nitrates.      | Nitrites. | Oxygen Consumed. | Hardness. |
|         |                     |             |                 |        |                              |                      |          | Total.     | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 10147   | 1893.<br>Mar. 21    | None.       | V. slight.      | 0.90   | 4.15                         | 1.45                 | .0000    | .0146      | .0128      | .0018           | .60       | .0030          | .0001     | .7452            | 0.8       |
| 10546   | June 21             | V. slight.  | Cons.,<br>dark. | 1.10   | 3.90                         | 1.90                 | .0002    | .0194      | .0160      | .0034           | .52       | .0000          | .0000     | .7939            | 0.3       |
| 11077   | Sept. 21            | V. slight.  | V. slight.      | 0.50   | 3.70                         | 1.65                 | .0006    | .0154      | .0132      | .0022           | .60       | .0000          | .0000     | .5986            | 0.5       |
| 11526   | Dec. 19             | V. slight.  | Slight.         | 0.55   | 3.70                         | 1.65                 | .0004    | .0158      | .0134      | .0024           | .57       | .0000          | .0000     | .6010            | 0.3       |
| Av..    | .....               | .....       | .....           | 0.76   | 3.86                         | 1.66                 | .0003    | .0163      | .0139      | .0025           | .57       | .0003          | .0000     | .6847            | 0.5       |

## WEYMOUTH.

*Chemical Examination of Water from Faucets in Weymouth, etc.—Concluded.**Averages of Analyses of Previous Years.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1887*   | 1887*               | -           | -         | 0.93   | 4.08                    | 1.75              | .0007    | .0219       | -          | -          | .47       | .0030       | -         | -                | -         |
| 1888†   | 1888†               | -           | -         | 0.88   | 4.15                    | 1.94              | .0020    | .0225       | -          | -          | .48       | .0074       | .0000     | -                | -         |
| 1889†   | 1889†               | -           | -         | 1.40   | -                       | -                 | .0000    | .0230       | .0220      | .0010      | -         | .0040       | .0000     | -                | -         |
| 1892    | 1892                | -           | -         | 0.94   | 3.82                    | 1.86              | .0000    | .0173       | .0156      | .0017      | .51       | .0077       | .0000     | -                | 0.4       |
| 1893    | 1893                | -           | -         | 0.76   | 3.86                    | 1.66              | .0003    | .0163       | .0139      | .0025      | .57       | .0008       | .0000     | .6847            | 0.5       |

\* June to December.

† January to May.

‡ July.

NOTE to analyses of 1893; Iron, .0182. Odor of the first sample, distinctly vegetable; of the second and last samples, faintly vegetable; of the third sample, none.—The samples were collected from faucets in the town.

*Microscopical Examination.*

Very few organisms were found in any of these samples.

## WATER SUPPLY OF WHITMAN.

The advice of the State Board of Health to the town of Whitman, with reference to taking an additional supply of water for that town from ponds in Pembroke, Hanson and neighboring towns, may be found on page 67 of this volume.

For analyses of samples of water from the various ponds mentioned in the reply of the Board, see *Abington, Hanson and Pembroke*. Analyses of samples of water from the present sources of supply are given below.

*Chemical Examination of Water from the Filler-Gallery of the Whitman Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1893.</b>        |                  |           |        |                         |          |             |           |             |           |                  |           |       |
| 10178   | Mar. 28             | V. slight.       | Slight.   | 0.25   | 3.50                    | .0022    | .0068       | .60       | .0150       | .0000     | .3175            | 1.3       | .0260 |
| 10566   | June 27             | Distinct.        | Slight.   | 1.10   | 6.70                    | .0032    | .0322       | .83       | .0000       | .0000     | .8216            | 1.9       | .0225 |
| 11057   | Sept. 20            | Distinct, milky. | Slight.   | 0.18   | 6.90                    | .0028    | .0238       | .99       | .0050       | .0001     | .5248            | 2.2       | .0720 |
| Av...   | .....               | .....            | .....     | 0.51   | 5.70                    | .0027    | .0209       | .81       | .0067       | .0000     | .5546            | 1.8       | .0402 |

## TAUNTON.

*Microscopical Examination of Water from Elder's Pond, Lakeville.*

[Number of organisms per cubic centimeter.]

|                                 | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|---------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                 | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .       | 26    | 27    | 27    | 23    | 29    | 26    | 31    | 29    | 25    | 31    | 27    | 26    |
| Number of sample, . . .         | 13712 | 13889 | 14037 | 14197 | 14376 | 14541 | 14729 | 14912 | 15238 | 15440 | 15611 | 15797 |
| PLANTS.                         |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . .             | 33    | 1     | 11    | 17    | 5     | 21    | 44    | 274   | 13    | 20    | 29    | 40    |
| Asterionella, . . . .           | 33    | 1     | 3     | 11    | 0     | 0     | 15    | 252   | 12    | 15    | 0     | 16    |
| Cyclotella, . . . .             | pr.   | 0     | 0     | 0     | 0     | 3     | 9     | 0     | 0     | 3     | 24    | 17    |
| Diatoma, . . . .                | 0     | 0     | 0     | 0     | 2     | 2     | 0     | 2     | 0     | 0     | 0     | 0     |
| Navicula, . . . .               | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 0     | 1     | 1     | 2     | 2     |
| Synedra, . . . .                | pr.   | 0     | 3     | 5     | 3     | 3     | 7     | 20    | 0     | 1     | 3     | 5     |
| Tabellaria, . . . .             | 0     | 0     | 5     | 1     | 0     | 13    | 9     | 0     | 0     | 0     | 0     | 0     |
| Cyanophyceæ, . . . .            | pr.   | 0     | 0     | 0     | 20    | 136   | 75    | 110   | 115   | 48    | 6     | 28    |
| Anabæna, . . . .                | 0     | 0     | 0     | 0     | 20    | 0     | 2     | 0     | 60    | 0     | 0     | 0     |
| Merismopedia, . . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 5     | 8     | 0     | 0     | 0     | 0     |
| Microcystis, . . . .            | pr.   | 0     | 0     | 0     | 0     | 136   | 68    | 84    | 52    | 48    | 6     | 28    |
| Oscillaria, . . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 18    | 3     | 0     | 0     | 0     |
| Algæ, . . . .                   | 10    | 0     | 2     | 0     | 20    | 7     | 31    | 29    | 10    | 0     | 1     | 12    |
| Glaucocapsa, . . . .            | 0     | 0     | 0     | 0     | 20    | 0     | 0     | 7     | 0     | 0     | 1     | 0     |
| Protococcus, . . . .            | 6     | 0     | 0     | 0     | 0     | 7     | 23    | 18    | 8     | 0     | 0     | 0     |
| Raphidium, . . . .              | 4     | 0     | 2     | 0     | 0     | 0     | 8     | 4     | 2     | 0     | 0     | 12    |
| ANIMALS.                        |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . . .              | 1     | 26    | 33    | 6     | 4     | 1     | 9     | 49    | 4     | 0     | 9     | 3     |
| Dinobryon, . . . .              | 0     | 19    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 8     | 0     |
| Dinobryon cases, . . . .        | pr.   | 5     | 32    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 3     |
| Encysted infusorian, . . . .    | 0     | 0     | 0     | 5     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Peridinium, . . . .             | 1     | 2     | 1     | 1     | 0     | 0     | 7     | 48    | 3     | 0     | 1     | 0     |
| Phacus, . . . .                 | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 1     | 0     | 0     | 0     |
| Trachelomonas, . . . .          | 0     | 0     | 0     | 0     | 0     | 1     | 2     | 0     | 0     | 0     | 0     | 0     |
| Vorticella, . . . .             | 0     | 0     | 0     | 0     | 4     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Vermes, Anurea, . . . .         | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 1     |
| Miscellaneous, Zoöglæa, . . . . | 42    | 9     | 36    | 0     | 40    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| TOTAL, . . . .                  | 86    | 36    | 82    | 23    | 80    | 165   | 159   | 462   | 143   | 68    | 45    | 84    |

WHITMAN.

*Chemical Examination of Water from Hobart's Pond, Whitman.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                     |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 10177   | 1893.<br>Mar. 25    | Slight.             | Slight.   | 0.50   | 3.75                            | 1.15                 | .0008    | .0174       | .0146      | .0028           | .61       | .0180          | .0000     | .4745            | 1.1       |
| 10565   | June 27             | Distinct,<br>green. | Slight.   | 1.10   | 6.85                            | 2.50                 | .0010    | .0392       | .0330      | .0062           | .82       | .0000          | .0000     | .8176            | 1.8       |
| 11056   | Sept. 20            | Slight.             | Slight.   | 0.40   | 6.25                            | 2.80                 | .0008    | .0362       | .0340      | .0022           | .98       | .0000          | .0000     | .6396            | 1.9       |
| Av.     | .....               | .....               | .....     | 0.67   | 5.62                            | 2.15                 | .0009    | .0309       | .0272      | .0037           | .80       | .0060          | .0000     | .6439            | 1.6       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 1.43 | 7.37 | 2.48 | .0127 | .0600 | -     | -     | .80 | .0063 | -     | -     | -   |
| - | 1888  | - | - | 1.02 | 6.01 | 2.20 | .0051 | .0407 | -     | -     | .70 | .0133 | .0002 | -     | -   |
| - | 1889  | - | - | 0.89 | 5.11 | 1.80 | .0037 | .0392 | .0327 | .0065 | .71 | .0089 | .0002 | -     | -   |
| - | 1890  | - | - | 0.57 | 6.11 | 2.54 | .0027 | .0319 | .0257 | .0062 | .69 | .0186 | .0002 | -     | 2.0 |
| - | 1891  | - | - | 0.64 | 5.34 | 2.02 | .0012 | .0334 | .0273 | .0061 | .68 | .0112 | .0001 | -     | 1.6 |
| - | 1893  | - | - | 0.67 | 5.62 | 2.15 | .0009 | .0309 | .0272 | .0037 | .80 | .0060 | .0000 | .6439 | 1.6 |

\* June, July, October and December.

NOTE to analyses of 1893; Iron, .0183. Odor, vegetable, becoming unpleasant in the first two samples on heating. — The samples were collected from the pond near the outlet.

*Microscopical Examination of Water from Hobart's Pond, Whitman.*

[Number of organisms per cubic centimeter.]

|                               |  | 1893.  |       |            |
|-------------------------------|--|--------|-------|------------|
|                               |  | March. | June. | September. |
| Day of examination, . . . . . |  | 29     | 27    | 21         |
| Number of sample, . . . . .   |  | 10177  | 10565 | 11056      |
| PLANTS.                       |  |        |       |            |
| Diatomaceæ, . . . . .         |  | 29     | 12    | 0          |
| Diatoma, . . . . .            |  | 8      | 0     | 0          |
| Melosira, . . . . .           |  | 0      | 8     | 0          |
| Meridion, . . . . .           |  | 3      | 0     | 0          |
| Synedra, . . . . .            |  | 14     | 3     | 0          |
| Tabellaria, . . . . .         |  | 4      | 1     | 0          |
| Algæ, . . . . .               |  | 11     | 3     | 44         |
| Chlorococcus, . . . . .       |  | 11     | 0     | 1          |
| Protococcus, . . . . .        |  | 0      | 0     | 43         |
| Staurostrum, . . . . .        |  | 0      | 3     | 0          |
| Fungi, Crenothrix, . . . . .  |  | 1      | 3     | 0          |

WHITMAN.

Microscopical Examination of Water from Hobart's Pond— Concluded.

[Number of organisms per cubic centimeter.]

|                                   | 1893.  |       |            |
|-----------------------------------|--------|-------|------------|
|                                   | March. | June. | September. |
| ANIMALS.                          |        |       |            |
| Rhizopoda, . . . . .              | 0      | 32    | 3          |
| Actinophrys, . . . . .            | 0      | 32    | 0          |
| Diffugia, . . . . .               | 0      | 0     | 3          |
| Infusoria, . . . . .              | 36     | 20    | 3          |
| Dinobryon cases, . . . . .        | 1      | 11    | 2          |
| Peridinium, . . . . .             | 84     | 8     | 1          |
| Trachelomonas, . . . . .          | 1      | 1     | 0          |
| Vermes, . . . . .                 | 0      | 14    | 0          |
| Anurea, . . . . .                 | 0      | 7     | 0          |
| Rotifer cases, . . . . .          | 0      | 7     | 0          |
| Miscellaneous, Zoöglas, . . . . . | 12     | 56    | 0          |
| TOTAL, . . . . .                  | 89     | 140   | 50         |

WATER SUPPLY OF WINCHESTER.

Chemical Examination of Water from the North Reservoir of the Winchester Water Works.

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|-------------------|--------|-------------------------|-------------------|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment.         | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                     |                   |        |                         |                   |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |           |
| 9851    | 1893.<br>Jan. 4     | Slight.             | Slight.           | .03    | 4.60                    | 1.60              | .0134    | .0174       | .0158      | .0016           | .47       | .0180       | .0001     | -                | 2.2       |
| 10080   | Mar. 6              | None.               | V. slight.        | .08    | 5.10                    | 1.40              | .0138    | .0400       | .0136      | .0264           | .60       | .0200       | .0002     | .0663            | 2.6       |
| 10351   | May 3               | Distinct.           | Cons.,<br>green.  | .08    | 5.35                    | 1.40              | .0022    | .0230       | .0154      | .0076           | .56       | .0250       | .0006     | .2482            | 1.9       |
| 10622   | July 10             | Slight.             | Slight.           | .08    | 5.20                    | 2.00              | .0010    | .0210       | .0182      | .0028           | .62       | .0050       | .0000     | .2555            | 2.3       |
| 10980   | Sept. 7             | Distinct,<br>green. | Slight,<br>green. | .12    | 5.20                    | 1.70              | .0020    | .0258       | .0200      | .0058           | .61       | .0030       | .0001     | .3320            | 2.4       |
| 11293   | Nov. 6              | Slight.             | Cons.             | .05    | 5.30                    | 1.60              | .0008    | .0240       | .0202      | .0038           | .69       | .0050       | .0000     | .3569            | 2.2       |
| Av..    | .....               | .....               | .....             | .07    | 5.13                    | 1.62              | .0055    | .0252       | .0172      | .0080           | .59       | .0127       | .0002     | .2718            | 2.3       |

## WINCHESTER.

*Chemical Examination of Water from the North Reservoir of the Winchester Water Works—Concluded.**Averages of Analyses of Previous Years.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1887*   |                     |             |           | .11    | 5.08                    | 1.18              | .0015    | .0196       | -          | -          | .53       | .0037       | -         | -                | -         |
| 1888    |                     |             |           | .15    | 4.93                    | 1.24              | .0045    | .0273       | -          | -          | .47       | .0131       | .0003     | -                | -         |
| 1889    |                     |             |           | .13    | 4.52                    | 1.18              | .0022    | .0223       | .0176      | .0047      | .47       | .0105       | .0003     | -                | -         |
| 1890    |                     |             |           | .09    | 5.30                    | 1.31              | .0017    | .0201       | .0160      | .0041      | .52       | .0153       | .0002     | -                | 2.7       |
| 1891    |                     |             |           | .10    | 4.94                    | 1.39              | .0034    | .0222       | .0169      | .0053      | .51       | .0152       | .0001     | -                | 2.1       |
| 1892    |                     |             |           | .06    | 5.23                    | 1.59              | .0058    | .0217       | .0177      | .0040      | .60       | .0192       | .0002     | -                | 2.5       |
| 1893    |                     |             |           | .07    | 5.13                    | 1.62              | .0055    | .0252       | .0172      | .0080      | .59       | .0127       | .0002     | .2718            | 2.3       |

\* June to December.

NOTE to analyses of 1893; Iron, .0057. Odor, vegetable, occasionally mouldy or unpleasant.—The samples were collected from the North Reservoir, near the gate-house, about one foot beneath the surface.

*Microscopical Examination of Water from the North Reservoir of the Winchester Water Works.*

[Number of organisms per cubic centimeter.]

|                             |           | 1893. |        |       |       |       |       |
|-----------------------------|-----------|-------|--------|-------|-------|-------|-------|
|                             |           | Jan.  | March. | May.  | June. | Sept. | Nov.  |
| Day of examination,         | . . . . . | 5     | 7      | 4     | 11    | 9     | 9     |
| Number of sample, . . . . . |           | 9851  | 10080  | 10851 | 10622 | 10980 | 11293 |
| PLANTS.                     |           |       |        |       |       |       |       |
| Diatomaceæ, . . . . .       |           | 42    | 2      | 5,764 | 0     | 8     | 171   |
| Asterionella, . . . . .     |           | 0     | 0      | 2,800 | 0     | 8     | 93    |
| Cyclotella, . . . . .       |           | 1     | 0      | 118   | 0     | 0     | 60    |
| Fragilaria, . . . . .       |           | 0     | 0      | 104   | 0     | 0     | 0     |
| Melosira, . . . . .         |           | 0     | 2      | 0     | 0     | 0     | 16    |
| Synedra, . . . . .          |           | 1     | 0      | 2,488 | 0     | 0     | 1     |
| Tabellaria, . . . . .       |           | 40    | 0      | 254   | 0     | 0     | 1     |
| Cyanophyceæ, . . . . .      |           | 1,268 | 0      | 42    | 1     | 2     | 37    |
| Anabæna, . . . . .          |           | 0     | 0      | 2     | 0     | 0     | 7     |
| Chroococcus, . . . . .      |           | 1,268 | 0      | 0     | 0     | 0     | 0     |
| Clothrocystis, . . . . .    |           | 0     | 0      | 0     | 1     | 2     | 1     |
| Cælophærium, . . . . .      |           | 0     | 0      | 0     | 0     | 0     | 19    |
| Hapalosiphon, . . . . .     |           | 0     | 0      | 40    | 0     | 0     | 0     |
| Microcystis, . . . . .      |           | 0     | 0      | 0     | 0     | 0     | 10    |
| Algæ, . . . . .             |           | 7     | 0      | 60    | 120   | 23    | 45    |
| Chlorococcus, . . . . .     |           | 3     | 0      | 6     | 0     | 7     | 12    |
| Closterium, . . . . .       |           | 0     | 0      | 32    | 74    | 1     | 1     |
| Hyalotheca, . . . . .       |           | 4     | 0      | 0     | 0     | 0     | 0     |
| Protococcus, . . . . .      |           | 0     | 0      | 21    | 46    | 5     | 30    |
| Raphidium, . . . . .        |           | 0     | 0      | 0     | 0     | 8     | 0     |
| Staurostrum, . . . . .      |           | 0     | 0      | 1     | 0     | 2     | 2     |

## WINCHESTER.

*Microscopical Examination of Water from the North Reservoir of the Winchester Water Works—Concluded.*

[Number of organisms per cubic centimeter.]

|                                      | 1893. |        |       |       |       |      |
|--------------------------------------|-------|--------|-------|-------|-------|------|
|                                      | Jan.  | March. | May.  | June. | Sept. | Nov. |
| <b>ANIMALS.</b>                      |       |        |       |       |       |      |
| <b>Rhizopoda, Actinophrys, . . .</b> | 3     | 0      | 4     | 0     | 0     | 0    |
| <b>Infusoria, . . . . .</b>          | 7     | 3      | 92    | 0     | 1,149 | 66   |
| Dinobryon, . . . . .                 | 0     | 0      | 66    | 0     | 0     | 0    |
| Dinobryon cases, . . . . .           | 1     | 0      | 2     | 0     | 1,120 | 36   |
| Peridinium, . . . . .                | 6     | 0      | 15    | 0     | 1     | 0    |
| Trachelomonas, . . . . .             | 0     | 3      | pr.   | 0     | 23    | 17   |
| Vorticella, . . . . .                | 0     | 0      | 9     | 0     | 0     | 13   |
| <b>Vermes, Rotifer, . . . . .</b>    | 0     | 0      | 0     | 1     | 0     | 0    |
| <b>Crustacea, Cyclops, . . . . .</b> | 0     | .10    | 0     | 0     | 0     | 0    |
| <b>Miscellaneous, . . . . .</b>      | 0     | .01    | 5     | 18    | 72    | 27   |
| Acarina, . . . . .                   | 0     | .01    | .04   | 0     | .01   | 0    |
| Zoöglæa, . . . . .                   | 0     | 0      | 5     | 18    | 72    | 27   |
| <b>TOTAL, . . . . .</b>              | 1,327 | 5      | 5,967 | 140   | 1,254 | 346  |

*Chemical Examination of Water from the South Reservoir of the Winchester Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrate.    | Nitrites. |                  |           |
|         |                     |             |                   |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1893.   |                     |             |                   |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 9852    | Jan. 4              | Slight.     | Slight.           | .45    | 3.85                    | 1.65              | .0156    | .0230       | .0146      | .0084      | .26       | .0150       | .0002     | -                | 1.3       |
| 10081   | Mar. 6              | V. slight.  | Slight.           | .55    | 5.35                    | 2.05              | .0066    | .0354       | .0124      | .0230      | .42       | .0180       | .0000     | .5256            | 2.3       |
| 10352   | May 3               | Distinct.   | Cons., green.     | .40    | 5.15                    | 1.95              | .0052    | .0262       | .0232      | .0030      | .34       | .0150       | .0005     | .4562            | 1.9       |
| 10623   | July 10             | Distinct.   | Slight, green.    | .15    | 4.80                    | 2.00              | .0000    | .0324       | .0278      | .0046      | .39       | .0000       | .0000     | .4161            | 2.1       |
| 10981   | Sept. 7             | V. slight.  | V. slight, green. | .18    | 4.65                    | 1.70              | .0022    | .0304       | .0276      | .0028      | .38       | .0030       | .0001     | .5080            | 2.1       |
| 11292   | Nov. 6              | Slight.     | Cons., green.     | .33    | 4.90                    | 1.80              | .0090    | .0270       | .0238      | .0032      | .39       | .0050       | .0004     | .5395            | 2.2       |
| Av..    | .....               | .....       | .....             | .34    | 4.78                    | 1.86              | .0064    | .0291       | .0216      | .0075      | .36       | .0093       | .0002     | .4891            | 2.1       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1891* | - | - | .60 | 5.73 | 2.09 | .0110 | .0486 | .0361 | .0125 | .40 | .0094 | .0006 | -     | 2.3 |
| - | 1892  | - | - | .51 | 5.17 | 2.04 | .0055 | .0392 | .0318 | .0074 | .38 | .0118 | .0002 | -     | 2.2 |
| - | 1893  | - | - | .34 | 4.78 | 1.86 | .0064 | .0291 | .0216 | .0075 | .36 | .0093 | .0002 | .4891 | 2.1 |

\* August to December.

NOTE to analyses of 1893; Iron, .0317. Odor, vegetable, becoming stronger and frequently unpleasant on heating.—The samples were collected from the reservoir near the gate-house, from six inches to three feet beneath the surface.

## WINCHESTER.

*Microscopical Examination of Water from the South Reservoir of the Winchester Water Works.*

[Number of organisms per cubic centimeter.]

|                                   | 1898. |        |       |       |       |       |
|-----------------------------------|-------|--------|-------|-------|-------|-------|
|                                   | Jan.  | March. | May.  | July. | Sept. | Nov.  |
| Day of examination, . . . . .     | 5     | 7      | 4     | 11    | 9     | 8     |
| Number of sample, . . . . .       | 9852  | 10081  | 10352 | 10623 | 10981 | 11292 |
| PLANTS.                           |       |        |       |       |       |       |
| Diatomaceæ, . . . . .             | 15    | 1      | 524   | pr.   | 2     | 461   |
| Asterionella, . . . . .           | 4     | 0      | 430   | 0     | 0     | 132   |
| Cyclotella, . . . . .             | 1     | 1      | 0     | 0     | 0     | 1     |
| Melowira, . . . . .               | 4     | 0      | 0     | 0     | 0     | 0     |
| Stephanodiscus, . . . . .         | 5     | 0      | 0     | 0     | 0     | 0     |
| Synedra, . . . . .                | 1     | pr.    | 94    | pr.   | 0     | 0     |
| Tabellaria, . . . . .             | 0     | 0      | 0     | 0     | 2     | 328   |
| Cyanophyceæ, . . . . .            | 0     | 0      | 0     | 114   | 14    | 38    |
| Anabæna, . . . . .                | 0     | 0      | 0     | 88    | 4     | 1     |
| Anabæna spores, . . . . .         | 0     | 0      | 0     | 0     | 0     | 30    |
| Nathrocyctis, . . . . .           | 0     | 0      | 0     | 2     | 10    | 1     |
| Microcyctis, . . . . .            | 0     | 0      | 0     | 0     | 0     | 4     |
| Oscillaria, . . . . .             | 0     | 0      | 0     | 24    | 0     | 0     |
| Algæ, . . . . .                   | 0     | 3      | 0     | 182   | 288   | 10    |
| Chlorococcus, . . . . .           | 0     | 0      | 0     | 0     | 0     | 3     |
| Closterium, . . . . .             | 0     | 3      | 0     | 180   | 288   | 2     |
| Protococcus, . . . . .            | 0     | 0      | 0     | 2     | 0     | 5     |
| ANIMALS.                          |       |        |       |       |       |       |
| Infusoria, . . . . .              | 1     | 4      | 181   | 0     | 148   | 7     |
| Dead Infusoria, . . . . .         | 0     | 0      | 2     | 0     | 0     | 0     |
| Dinobryon, . . . . .              | 0     | 0      | 178   | 0     | 0     | 0     |
| Dinobryon cases, . . . . .        | 0     | 0      | 1     | 0     | 144   | 0     |
| Euglena, . . . . .                | 0     | 0      | 0     | 0     | 0     | 1     |
| Peridinium, . . . . .             | 1     | 0      | 0     | 0     | 2     | 0     |
| Trachelomonas, . . . . .          | 0     | 4      | pr.   | 0     | 2     | 4     |
| Vorticella, . . . . .             | 0     | 0      | 0     | 0     | 0     | 2     |
| Vermes, . . . . .                 | 0     | 1      | 3     | 1     | 0     | 2     |
| Anurea, . . . . .                 | 0     | 1      | 0     | 1     | 0     | 1     |
| Monocerca, . . . . .              | 0     | 0      | 0     | 0     | 0     | 1     |
| Rotatorian ova, . . . . .         | 0     | pr.    | 1     | 0     | 0     | 0     |
| Bacculus, . . . . .               | 0     | 0      | 2     | 0     | 0     | 0     |
| Miscellaneous, Zoöglæa, . . . . . | 0     | 0      | 116   | 36    | 21    | 116   |
| TOTAL, . . . . .                  | 16    | 9      | 824   | 309   | 473   | 632   |



## WOBBURN.

## WATER SUPPLY OF WOBURN.

*Chemical Examination of Water from the Filter-Gallery of the Woburn Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Fres.    | Alb.-minfold. |           | Nitrates.   | Nitrites. |                  |           |       |
| 9925    | 1893.<br>Jan. 24    | None.       | None.     | .00    | 11.45                   | .0030    | .0022         | 2.08      | .0600       | .0001     | .0511            | 5.3       | .0000 |
| 10076   | Mar. 3              | None.       | None.     | .00    | 11.25                   | .0026    | .0008         | 2.10      | .0450       | .0000     | .0144            | 5.9       | .0000 |
| 10156   | Mar. 22             | None.       | None.     | .00    | 11.80                   | .0028    | .0016         | 2.15      | .0500       | .0000     | .0000            | 5.0       | .0000 |
| 10312   | Apr. 25             | None.       | None.     | .00    | 10.80                   | .0016    | .0018         | 2.07      | .0450       | .0000     | .0474            | 4.9       | .0000 |
| 10453   | May 24              | None.       | None.     | .02    | 10.95                   | .0006    | .0012         | 1.77      | .0650       | .0000     | .0713            | 5.3       | .0000 |
| 10553   | June 21             | None.       | None.     | .00    | 11.10                   | .0018    | .0020         | 1.97      | .0600       | .0000     | .0671            | 4.7       | .0020 |
| 10688   | July 19             | None.       | None.     | .00    | 11.50                   | .0020    | .0016         | 2.00      | .0300       | .0000     | .0000            | 5.0       | .0000 |
| 10877   | Aug. 23             | None.       | None.     | .00    | 12.00                   | .0034    | .0008         | 2.00      | .0400       | .0001     | .0632            | 5.2       | .0000 |
| 11076   | Sept. 20            | None.       | None.     | .00    | 11.75                   | .0022    | .0012         | 2.00      | .0350       | .0000     | .0697            | 5.7       | .0000 |
| 11211   | Oct. 17             | None.       | None.     | .00    | 11.70                   | .0024    | .0012         | 2.18      | .0250       | .0000     | .0729            | 5.4       | .0030 |
| 11379   | Nov. 22             | None.       | None.     | .00    | 12.10                   | .0018    | .0038         | 2.14      | .0430       | .0000     | .1176            | 5.6       | .0000 |
| 11554   | Dec. 26             | None.       | None.     | .00    | 11.55                   | .0026    | .0034         | 2.07      | .0380       | .0000     | .0462            | 5.0       | .0000 |
| Av.     | .....               | .....       | .....     | .00    | 11.50                   | .0022    | .0018         | 2.04      | .0447       | .0000     | .0517            | 5.3       | .0004 |

*Averages of Analyses of Previous Years.*

|   |       |   |   |     |       |       |       |      |       |       |       |     |       |
|---|-------|---|---|-----|-------|-------|-------|------|-------|-------|-------|-----|-------|
| - | 1887* | - | - | .00 | 12.06 | -     | .0028 | 2.40 | .0314 | -     | -     | -   | -     |
| - | 1888  | - | - | .00 | 12.00 | .0012 | .0032 | 2.50 | .0346 | .0000 | -     | -   | -     |
| - | 1889  | - | - | .00 | 10.84 | .0010 | .0022 | 2.07 | .0372 | .0000 | -     | -   | -     |
| - | 1890  | - | - | .01 | 11.06 | .0012 | .0023 | 1.91 | .0431 | .0000 | -     | 5.0 | -     |
| - | 1891  | - | - | .00 | 10.85 | .0008 | .0015 | 1.79 | .0638 | .0000 | -     | 4.9 | -     |
| - | 1892  | - | - | .00 | 11.27 | .0012 | .0024 | 1.95 | .0542 | .0000 | -     | 5.1 | -     |
| - | 1893  | - | - | .00 | 11.50 | .0022 | .0018 | 2.04 | .0447 | .0000 | .0517 | 5.3 | .0004 |

\* June to December.

NOTE to analyses of 1893; Odor, none. — The samples were collected from the filter gallery.

*Microscopical Examination.*

No organisms.

## WOBURN.

*Chemical Examination of Water from Horn Pond, Woburn.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.     |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-----------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.      | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                 |                |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 9924    | 1893.<br>Jan. 24    | Distinct.       | Heavy, green.  | .40    | 13.50                   | 3.20              | .0008    | .0842       | .0310      | .0532      | 3.03      | .0950       | .0005     | .5402            | 3.9       |
| 10155   | Mar. 22             | Distinct.       | Slight.        | .40    | 4.75                    | 1.85              | .0134    | .0208       | .0158      | .0050      | 0.67      | .0300       | .0000     | .4140            | 1.8       |
| 10173   | Mar. 27             | Decided, green. | Slight, green. | .50    | 6.30                    | 2.40              | .0118    | .0190       | .0164      | .0028      | 0.86      | .0800       | .0001     | .4161            | 1.9       |
| 10311   | Apr. 25             | Slight.         | Heavy, green.  | .40    | 9.85                    | 2.10              | .0006    | .0484       | .0240      | .0244      | 3.29      | .0800       | .0021     | .4343            | 2.9       |
| 10452   | May 24              | Distinct.       | Cons.          | .50    | 8.45                    | 2.70              | .0076    | .0258       | .0176      | .0082      | 1.64      | .0700       | .0009     | .5400            | 2.6       |
| 10552   | June 21             | Distinct.       | Cons., green.  | .30    | 9.40                    | 3.05              | .0074    | .0338       | .0230      | .0108      | 1.97      | .0700       | .0028     | .4503            | 2.8       |
| 10687   | July 19             | Decided.        | Cons.          | .20    | 10.25                   | 2.85              | .0082    | .0858       | .0482      | .0376      | 2.08      | .0400       | .0008     | .3996            | 3.2       |
| 10876   | Aug. 23             | Decided, green. | Slight, green. | .30    | 10.55                   | 2.75              | .0000    | .0544       | .0268      | .0276      | 2.31      | .0050       | .0008     | .4424            | 3.3       |
| 11075   | Sept. 20            | Decided, green. | Cons., green.  | .12    | 10.05                   | 2.30              | .0030    | .0660       | .0266      | .0394      | 2.19      | .0070       | .0003     | .4264            | 3.5       |
| 11210   | Oct. 17             | Slight.         | Slight.        | .18    | 10.75                   | 2.60              | .0170    | .0314       | .0238      | .0076      | 2.43      | .0090       | .0008     | .4131            | 3.8       |
| 11378   | Nov. 22             | Distinct.       | Slight.        | .15    | 10.00                   | 1.75              | .0004    | .0278       | .0164      | .0114      | 2.37      | .0180       | .0009     | .4704            | 3.5       |
| 11553   | Dec. 26             | Slight.         | Slight.        | .33    | 9.80                    | 2.15              | .0094    | .0232       | .0182      | .0050      | 2.04      | .0700       | .0000     | .4889            | 3.4       |
| Av.     | .....               | .....           | .....          | .30    | 9.83                    | 2.51              | .0061    | .0455       | .0247      | .0208      | 2.10      | .0472       | .0009     | .4530            | 3.2       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |     |       |      |       |       |       |       |      |       |       |       |     |
|---|-------|---|---|-----|-------|------|-------|-------|-------|-------|------|-------|-------|-------|-----|
| - | 1887* | - | - | .44 | 13.79 | 2.19 | .0149 | .0480 | -     | -     | 3.74 | .0224 | .0014 | -     | -   |
| - | 1888  | - | - | .32 | 11.28 | 1.71 | .0186 | .0383 | -     | -     | 2.98 | .0398 | .0015 | -     | -   |
| - | 1889  | - | - | .30 | 8.37  | 2.03 | .0092 | .0376 | .0216 | .0160 | 1.98 | .0498 | .0015 | -     | -   |
| - | 1890  | - | - | .27 | 10.76 | 2.07 | .0080 | .0368 | .0205 | .0163 | 1.91 | .0581 | .0008 | -     | 3.4 |
| - | 1891  | - | - | .22 | 8.90  | 2.06 | .0129 | .0453 | .0237 | .0216 | 1.76 | .0502 | .0009 | -     | 2.9 |
| - | 1892  | - | - | .25 | 10.57 | 2.13 | .0110 | .0358 | .0216 | .0142 | 2.42 | .0821 | .0008 | -     | 3.3 |
| - | 1893  | - | - | .30 | 9.83  | 2.51 | .0061 | .0455 | .0247 | .0208 | 2.10 | .0472 | .0009 | .4530 | 3.2 |

\* June to December.

NOTE to analyses of 1893; Iron, .0078. Odor, distinctly vegetable and frequently unpleasant; on heating, the odor is generally stronger and frequently also disagreeable. — The first two samples were collected from the pond about one hundred feet from the shore near the pumping station of the Woburn Water Works; the remaining samples from the pond near its outlet. The samples were collected about one foot beneath the surface.

## WOBBURN.

*Microscopical Examination of Water from Horn Pond, Woburn.*

[Number of organisms per cubic centimeter.]

|                                      | 1893.        |            |            |            |            |              |            |              |            |            |              |            |
|--------------------------------------|--------------|------------|------------|------------|------------|--------------|------------|--------------|------------|------------|--------------|------------|
|                                      | Jan.         | Mar.       | Mar.       | Apr.       | May.       | June.        | July.      | Aug.         | Sept.      | Oct.       | Nov.         | Dec.       |
| Day of examination, . . .            | 25           | 24         | 29         | 27         | 26         | 23           | 21         | 24           | 22         | 19         | 24           | 28         |
| Number of sample, . . .              | 9924         | 10155      | 10173      | 10311      | 10452      | 10552        | 10687      | 10876        | 11075      | 11210      | 11378        | 11533      |
| <b>PLANTS.</b>                       |              |            |            |            |            |              |            |              |            |            |              |            |
| <b>Diatomaceæ, . . .</b>             | <b>122</b>   | <b>1</b>   | <b>6</b>   | <b>216</b> | <b>492</b> | <b>1,045</b> | <b>0</b>   | <b>10</b>    | <b>0</b>   | <b>613</b> | <b>1,485</b> | <b>224</b> |
| Asterionella, . . .                  | 112          | 1          | 4          | 118        | 24         | 2            | 0          | 0            | 0          | 31         | 320          | 10         |
| Cyclotella, . . .                    | 0            | 0          | 0          | 5          | 0          | 0            | 0          | 0            | 0          | 1          | 0            | 0          |
| Diatoma, . . .                       | 10           | 0          | 0          | 2          | 1          | 0            | 0          | 0            | 0          | 5          | 2            | 0          |
| Fragilaria, . . .                    | 0            | 0          | 0          | 0          | 380        | 1,040        | 0          | 10           | 0          | 520        | 61           | 8          |
| Melosira, . . .                      | 0            | 0          | 1          | 9          | 5          | 0            | 0          | 0            | 0          | 8          | 0            | 29         |
| Meridion, . . .                      | 0            | 0          | 0          | 4          | pr.        | 0            | 0          | 0            | 0          | 0          | 960          | 1          |
| Synedra, . . .                       | 0            | 0          | 1          | 78         | 82         | 3            | 0          | 0            | 0          | 48         | 152          | 176        |
| <b>Cyanophyceæ, . . .</b>            | <b>0</b>     | <b>0</b>   | <b>0</b>   | <b>0</b>   | <b>1</b>   | <b>1,276</b> | <b>87</b>  | <b>137</b>   | <b>732</b> | <b>11</b>  | <b>0</b>     | <b>18</b>  |
| Anabaena, . . .                      | 0            | 0          | 0          | 0          | 0          | 1,120        | 40         | 84           | 560        | 3          | 0            | 1          |
| Anabaena spores, . . .               | 0            | 0          | 0          | 0          | 0          | 0            | 0          | 13           | 164        | 0          | 0            | 0          |
| Clothrocystis, . . .                 | 0            | 0          | 0          | 0          | 1          | 60           | 44         | 40           | 8          | 8          | 0            | 1          |
| Cœlosphaerium, . . .                 | 0            | 0          | 0          | 0          | 0          | 96           | 3          | 0            | 0          | 0          | 0            | 16         |
| <b>Algæ, . . .</b>                   | <b>0</b>     | <b>2</b>   | <b>0</b>   | <b>4</b>   | <b>31</b>  | <b>53</b>    | <b>162</b> | <b>1,282</b> | <b>8</b>   | <b>147</b> | <b>50</b>    | <b>25</b>  |
| Arthrodesmus, . . .                  | 0            | 0          | 0          | 0          | 0          | 0            | 0          | 5            | 0          | 1          | 0            | 0          |
| Chlorococcus, . . .                  | 0            | 0          | 0          | 1          | 0          | 0            | 2          | 0            | 0          | 0          | 44           | 3          |
| Closterium, . . .                    | 0            | 0          | 0          | 0          | 0          | 0            | 0          | 0            | 0          | 0          | 0            | 6          |
| Cosmarium, . . .                     | 0            | 0          | 0          | 0          | 1          | 9            | 2          | 300          | 0          | 0          | 1            | 0          |
| Gloeocystis, . . .                   | 0            | 0          | 0          | 0          | 0          | 0            | 56         | 1            | 0          | 0          | 0            | 0          |
| Pandorina, . . .                     | 0            | 0          | 0          | 0          | 0          | 0            | 0          | 6            | 0          | 0          | 0            | 0          |
| Pediastrum, . . .                    | 0            | 0          | 0          | 0          | 1          | 6            | 1          | 2            | 0          | 3          | 0            | 0          |
| Protococcus, . . .                   | 0            | 0          | 0          | 0          | 0          | 19           | 52         | 0            | 0          | 0          | 0            | 14         |
| Scenedesmus, . . .                   | 0            | 0          | 0          | 1          | 28         | 14           | 5          | 920          | 6          | 136        | 5            | 2          |
| Staurostrum, . . .                   | 0            | 0          | 0          | 0          | 1          | 3            | 44         | 48           | 0          | 2          | 0            | 0          |
| Zoospores, . . .                     | 0            | 2          | 0          | 2          | pr.        | 2            | 0          | 0            | 0          | 5          | 0            | 0          |
| <b>Fungi, Crenothrix, . . .</b>      | <b>0</b>     | <b>pr.</b> | <b>0</b>   | <b>0</b>   | <b>3</b>   | <b>0</b>     | <b>0</b>   | <b>0</b>     | <b>0</b>   | <b>0</b>   | <b>2</b>     | <b>8</b>   |
| <b>ANIMALS.</b>                      |              |            |            |            |            |              |            |              |            |            |              |            |
| <b>Rhizopoda, . . .</b>              | <b>0</b>     | <b>0</b>   | <b>0</b>   | <b>2</b>   | <b>0</b>   | <b>0</b>     | <b>0</b>   | <b>0</b>     | <b>0</b>   | <b>2</b>   | <b>4</b>     | <b>5</b>   |
| Arcella, . . .                       | 0            | 0          | 0          | 0          | 0          | 0            | 0          | 0            | 0          | 2          | 0            | 0          |
| Diffugia, . . .                      | 0            | 0          | 0          | 2          | 0          | 0            | 0          | 0            | 0          | 0          | 4            | 5          |
| <b>Infusoria, . . .</b>              | <b>7,324</b> | <b>5</b>   | <b>0</b>   | <b>1</b>   | <b>2</b>   | <b>3</b>     | <b>5</b>   | <b>0</b>     | <b>0</b>   | <b>2</b>   | <b>7</b>     | <b>13</b>  |
| Cryptomonas, . . .                   | 7,524        | 5          | 0          | 0          | 0          | 0            | 0          | 0            | 0          | 0          | 0            | 3          |
| Monas, . . .                         | 0            | 0          | 0          | 0          | 2          | 0            | 0          | 0            | 0          | 0          | 0            | 0          |
| Peridinium, . . .                    | 0            | 0          | 0          | 1          | 0          | 0            | 0          | 0            | 0          | 2          | 2            | 0          |
| Synura, . . .                        | 0            | 0          | 0          | 0          | 0          | 3            | 5          | 0            | 0          | 0          | 0            | 2          |
| Trachelomonas, . . .                 | 0            | 0          | 0          | 0          | 0          | 0            | 0          | 0            | 0          | 0          | 5            | 3          |
| Vorticella stems, . . .              | 0            | 0          | 0          | 0          | 0          | 0            | 0          | 0            | 0          | 0          | 0            | 5          |
| <b>Vermes, . . .</b>                 | <b>0</b>     | <b>pr.</b> | <b>0</b>   | <b>0</b>   | <b>pr.</b> | <b>0</b>     | <b>24</b>  | <b>2</b>     | <b>0</b>   | <b>0</b>   | <b>1</b>     | <b>3</b>   |
| Aurea, . . .                         | 0            | 0          | 0          | 0          | pr.        | 0            | 0          | 0            | 0          | 0          | 1            | 1          |
| Polyarthra, . . .                    | 0            | 0          | 0          | 0          | 0          | 0            | 0          | 2            | 0          | 0          | 0            | 0          |
| Rotatorian ova, . . .                | 0            | pr.        | 0          | 0          | 0          | 0            | 24         | 0            | 0          | 0          | 0            | 2          |
| <b>Miscellaneous, Zoöglaa, . . .</b> | <b>9</b>     | <b>166</b> | <b>176</b> | <b>16</b>  | <b>38</b>  | <b>4</b>     | <b>0</b>   | <b>48</b>    | <b>0</b>   | <b>5</b>   | <b>52</b>    | <b>0</b>   |
| <b>TOTAL, . . .</b>                  | <b>7,655</b> | <b>174</b> | <b>182</b> | <b>239</b> | <b>567</b> | <b>2,381</b> | <b>278</b> | <b>1,479</b> | <b>738</b> | <b>780</b> | <b>1,001</b> | <b>296</b> |

## WORCESTER.

## WATER SUPPLY OF WORCESTER.

During the past year the raising of the dam of the Holden storage reservoir has been completed and the capacity of the reservoir increased by nearly 300,000,000 gallons. The work consisted of strengthening the dam on the lower side by widening its base and increasing its height to a level of ten feet above the old dam, allowing the latter to form a berme in the completed structure. The area of the reservoir is now 149.5 acres, and its capacity 742,000,000 gallons. Its greatest depth is 30.1 feet and its average depth about 15.2 feet. The area newly flowed has been prepared by removing the trees and bushes and much other objectionable material, and by covering the swampy places with gravel.

LEICESTER SUPPLY—*Chemical Examination of Water from the Lynde Brook Storage Reservoir.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                    |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|--------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.          | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |                    |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1893.   |                     |             |                    |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 9908    | Jan. 20             | Slight.     | Slight.            | 0.45   | 3.40                            | 1.10                 | .0062    | .0140       | .0126      | .0014           | .13       | .0050          | .0001     | .4307            | 0.7       |
| 10000   | Feb. 14             | Distinct.   | Slight.            | 0.30   | 2.70                            | 1.10                 | .0010    | .0240       | .0138      | .0102           | .16       | .0050          | .0001     | .4307            | 0.6       |
| 10139   | Mar. 16             | Slight.     | Slight.<br>clayey. | 0.33   | 2.70                            | 1.10                 | .0030    | .0146       | .0116      | .0030           | .15       | .0100          | .0000     | .3348            | 0.6       |
| 10388   | May 15              | V. slight.  | Slight.            | 0.20   | 2.50                            | 0.90                 | .0000    | .0134       | .0110      | .0024           | .11       | .0150          | .0001     | .3102            | 0.5       |
| 10531   | June 19             | Distinct.   | Cons.,<br>yellow.  | 0.20   | 2.35                            | 1.00                 | .0014    | .0232       | .0168      | .0064           | .16       | .0030          | .0000     | .3216            | 0.5       |
| 10669   | July 17             | V. slight.  | Slight.            | 0.05   | 2.50                            | 1.25                 | .0004    | .0186       | .0134      | .0052           | .15       | .0030          | .0000     | .3042            | 0.3       |
| 10872   | Aug. 22             | Slight.     | Slight,<br>white.  | 0.10   | 2.45                            | 1.35                 | .0000    | .0122       | .0106      | .0016           | .15       | .0000          | .0000     | .3002            | 0.5       |
| 11042   | Sept. 18            | Slight.     | Slight,<br>yellow. | 0.15   | 2.60                            | 0.15                 | .0004    | .0158       | .0130      | .0025           | .18       | .0000          | .0000     | .3276            | 0.6       |
| 11200   | Oct. 16             | Distinct.   | Cons.              | 0.42   | 2.75                            | 1.05                 | .0094    | .0162       | .0114      | .0048           | .14       | .0050          | .0000     | .3199            | 0.5       |
| 11352   | Nov. 20             | Slight.     | Slight.            | 0.48   | 2.95                            | 1.00                 | .0102    | .0142       | .0104      | .0038           | .15       | .0070          | .0001     | .4158            | 0.9       |
| 11512   | Dec. 18             | Slight.     | V. slight.         | 0.20   | 2.35                            | 0.75                 | .0072    | .0116       | .0100      | .0016           | .14       | .0200          | .0004     | .3159            | 0.5       |
| Av..    | .....               | .....       | .....              | 0.26   | 2.66                            | 0.98                 | .0036    | .0162       | .0122      | .0039           | .15       | .0066          | .0001     | .3465            | 0.6       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 0.30 | 3.15 | 0.95 | .0057 | .0194 | -     | -     | .15 | .0043 | -     | -     | -   |
| - | 1888  | - | - | 0.24 | 2.64 | 0.85 | .0037 | .0151 | -     | -     | .14 | .0065 | .0001 | -     | -   |
| - | 1889  | - | - | 0.24 | 2.54 | 0.60 | .0030 | .0167 | .0138 | .0029 | .15 | .0053 | .0001 | -     | -   |
| - | 1890  | - | - | 0.21 | 3.07 | 1.15 | .0026 | .0132 | .0107 | .0025 | .14 | .0078 | .0001 | -     | 0.9 |
| - | 1891  | - | - | 0.24 | 2.83 | 1.03 | .0045 | .0126 | .0101 | .0025 | .12 | .0074 | .0001 | -     | 0.7 |
| - | 1892  | - | - | 0.25 | 2.99 | 1.15 | .0038 | .0139 | .0113 | .0026 | .16 | .0105 | .0000 | -     | 0.8 |
| - | 1893  | - | - | 0.26 | 2.66 | 0.98 | .0036 | .0162 | .0122 | .0039 | .15 | .0066 | .0001 | .3465 | 0.6 |

\* June to December.

NOTE to analyses of 1893; Iron, .0219. Odor, vegetable, rarely unpleasant, sometimes none; on heating, the odor is somewhat stronger and frequently unpleasant.—The samples were collected from the reservoir near the gate-house about one foot beneath the surface.

**WORCESTER.***Microscopical Examination of Water from the Lynde Brook Storage Reservoir.*

[Number of organisms per cubic centimeter.]

|                                  | 1893.     |            |            |            |            |            |            |            |            |            |           |
|----------------------------------|-----------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-----------|
|                                  | Jan.      | Feb.       | Mar.       | May.       | June.      | July.      | Aug.       | Sept.      | Oct.       | Nov.       | Dec.      |
| Day of examination, . . .        | 21        | 16         | 21         | 16         | 21         | 19         | 24         | 19         | 17         | 22         | 20        |
| Number of sample, . . .          | 9908      | 10000      | 10139      | 10388      | 10531      | 10669      | 10872      | 11042      | 11200      | 11352      | 11512     |
| <b>PLANTS.</b>                   |           |            |            |            |            |            |            |            |            |            |           |
| <b>Diatomaceæ, . . .</b>         | <b>23</b> | <b>pr.</b> | <b>0</b>   | <b>64</b>  | <b>34</b>  | <b>48</b>  | <b>76</b>  | <b>0</b>   | <b>30</b>  | <b>50</b>  | <b>15</b> |
| Asterionella, . . .              | 21        | 0          | 0          | 34         | 5          | 0          | 0          | 0          | 0          | 10         | 14        |
| Cyclotella, . . .                | 1         | 0          | 0          | 0          | 28         | 48         | 76         | 0          | 4          | 9          | 1         |
| Melosira, . . .                  | 0         | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 25         | 30         | 0         |
| Synedra, . . .                   | 1         | pr.        | 0          | 30         | 1          | 0          | 0          | 0          | 1          | 1          | 0         |
| <b>Cyanophyceæ, . . .</b>        | <b>0</b>  | <b>0</b>   | <b>0</b>   | <b>0</b>   | <b>235</b> | <b>pr.</b> | <b>35</b>  | <b>23</b>  | <b>86</b>  | <b>2</b>   | <b>0</b>  |
| Anabæna, . . .                   | 0         | 0          | 0          | 0          | 46         | 0          | 0          | 2          | 1          | 0          | 0         |
| Anabæna spores, . . .            | 0         | 0          | 0          | 0          | 57         | 0          | 0          | 0          | 0          | 0          | 0         |
| Chroococcus, . . .               | 0         | 0          | 0          | 0          | 132        | 0          | 28         | 3          | 85         | 2          | 0         |
| Merismopædia, . . .              | 0         | 0          | 0          | 0          | 0          | pr.        | 4          | 13         | 0          | 0          | 0         |
| Microcystis, . . .               | 0         | 0          | 0          | 0          | 0          | 0          | 3          | 5          | 0          | 0          | 0         |
| <b>Algæ, . . .</b>               | <b>1</b>  | <b>0</b>   | <b>0</b>   | <b>27</b>  | <b>325</b> | <b>158</b> | <b>105</b> | <b>76</b>  | <b>24</b>  | <b>90</b>  | <b>0</b>  |
| Botryococcus, . . .              | 0         | 0          | 0          | 0          | 0          | 0          | 74         | 60         | 0          | 0          | 0         |
| Chlorococcus, . . .              | 0         | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 21         | 0          | 0         |
| Oöcystis, . . .                  | 0         | 0          | 0          | 0          | 0          | 154        | 0          | 0          | 0          | 0          | 0         |
| Protococcus, . . .               | 0         | 0          | 0          | 10         | 64         | 0          | 0          | 0          | 0          | 0          | 0         |
| Raphidium, . . .                 | 0         | 0          | 0          | 0          | 4          | 4          | 30         | 3          | 0          | 0          | 0         |
| Sphærozosma, . . .               | 0         | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 88         | 0         |
| Staurogenia, . . .               | 0         | 0          | 0          | 0          | 256        | 0          | 1          | 12         | 0          | 0          | 0         |
| Zoöspores, . . .                 | 1         | 0          | 0          | 7          | 1          | pr.        | 0          | 1          | 3          | 2          | 0         |
| <b>ANIMALS.</b>                  |           |            |            |            |            |            |            |            |            |            |           |
| <b>Rhizopoda, Actinophrys, .</b> | <b>0</b>  | <b>0</b>   | <b>0</b>   | <b>1</b>   | <b>0</b>   | <b>0</b>   | <b>pr.</b> | <b>0</b>   | <b>0</b>   | <b>0</b>   | <b>0</b>  |
| <b>Infusoria, . . .</b>          | <b>2</b>  | <b>30</b>  | <b>pr.</b> | <b>28</b>  | <b>14</b>  | <b>1</b>   | <b>1</b>   | <b>2</b>   | <b>4</b>   | <b>1</b>   | <b>1</b>  |
| Dinobryon cases, . . .           | 0         | 0          | 0          | 26         | 13         | 0          | 0          | 0          | 0          | 0          | 0         |
| Monas, . . .                     | 0         | 0          | 0          | 0          | 1          | 1          | 0          | 0          | 0          | 0          | 1         |
| Peridinium, . . .                | 2         | 30         | pr.        | 2          | 0          | pr.        | 1          | 2          | 4          | 1          | 0         |
| <b>Vermes, . . .</b>             | <b>0</b>  | <b>4</b>   | <b>pr.</b> | <b>0</b>   | <b>0</b>   | <b>0</b>   | <b>0</b>   | <b>0</b>   | <b>0</b>   | <b>0</b>   | <b>0</b>  |
| Anurea, . . .                    | 0         | 2          | pr.        | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 0         |
| Polyarthra, . . .                | 0         | 2          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 0         |
| <b>Miscellaneous, Zoöglæa, .</b> | <b>0</b>  | <b>926</b> | <b>18</b>  | <b>7</b>   | <b>0</b>   | <b>14</b>  | <b>0</b>   | <b>10</b>  | <b>160</b> | <b>56</b>  | <b>8</b>  |
| <b>TOTAL, . . .</b>              | <b>26</b> | <b>960</b> | <b>18</b>  | <b>127</b> | <b>608</b> | <b>221</b> | <b>217</b> | <b>111</b> | <b>304</b> | <b>199</b> | <b>24</b> |

## WORCESTER.

HOLDEN SUPPLY — *Chemical Examination of Water from the Talnuck Brook Storage Reservoir.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                    |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|--------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment.          | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                     |                    |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 9907    | 1893.<br>Jan. 20    | Slight.             | Slight.            | 0.40   | 2.90                    | 1.00              | .0030    | .0124       | .0108      | .0016      | .11       | .0100       | .0001     | .4380            | 0.5       |
| 9999    | Feb. 14             | V. slight.          | Slight.            | 0.30   | 2.90                    | 0.95              | .0096    | .0150       | .0128      | .0022      | .16       | .0070       | .0001     | .2920            | 0.8       |
| 10138   | Mar. 16             | Slight,<br>clayey.  | Slight.            | 0.30   | 2.05                    | 0.80              | .0024    | .0104       | .0086      | .0018      | .14       | .0070       | .0000     | .2916            | 0.5       |
| 10258   | Apr. 17             | Slight.             | Slight.            | 0.15   | 2.55                    | 1.00              | .0000    | .0062       | .0048      | .0014      | .12       | .0070       | .0000     | .2774            | 0.2       |
| 10389   | May 15              | Slight.             | Cons.              | 0.20   | 1.95                    | 0.65              | .0004    | .0176       | .0144      | .0032      | .10       | .0000       | .0000     | .3086            | 0.5       |
| 10532   | June 19             | Distinct.           | Cons.,<br>white.   | 0.35   | 2.10                    | 0.75              | .0042    | .0188       | .0144      | .0044      | .17       | .0050       | .0000     | .3417            | 0.5       |
| 10670   | July 17             | Slight.             | Slight.            | 0.30   | 2.60                    | 1.40              | .0016    | .0228       | .0210      | .0018      | .14       | .0030       | .0000     | .3666            | 0.1       |
| 10878   | Aug. 22             | Distinct,<br>green. | Cons.,<br>green.   | 0.40   | 2.65                    | 1.05              | .0000    | .0198       | .0148      | .0050      | .14       | .0030       | .0000     | .3713            | 0.5       |
| 11041   | Sept. 18            | Distinct.           | Slight,<br>yellow. | 0.55   | 2.55                    | 0.80              | .0008    | .0244       | .0172      | .0072      | .12       | .0030       | .0000     | .3627            | 0.6       |
| 11291   | Oct. 16             | Distinct.           | Cons.,<br>green.   | 0.50   | 2.25                    | 0.80              | .0000    | .0286       | .0196      | .0090      | .16       | .0000       | .0000     | .3807            | 1.1       |
| 11353   | Nov. 20             | Distinct.           | Cons.              | 0.45   | 2.30                    | 0.95              | .0000    | .0222       | .0142      | .0080      | .16       | .0060       | .0000     | .4746            | 0.6       |
| 11513   | Dec. 18             | Slight.             | V. slight.         | 0.30   | 2.65                    | 1.05              | .0016    | .0206       | .0155      | .0048      | .16       | .0080       | .0001     | .4090            | 0.5       |
| Av..    | .....               | .....               | .....              | 0.35   | 2.45                    | 0.93              | .0020    | .0182       | .0140      | .0042      | .14       | .0049       | .0000     | .3594            | 0.5       |

*Averages of Analyses of Previous Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 0.29 | 2.62 | 1.01 | .0007 | .0197 | -     | -     | .14 | .0016 | -     | -     | -   |
| - | 1888  | - | - | 0.17 | 2.23 | 0.75 | .0012 | .0157 | -     | -     | .12 | .0043 | .0001 | -     | -   |
| - | 1889  | - | - | 0.19 | 2.04 | 0.57 | .0003 | .0143 | .0112 | .0031 | .12 | .0031 | .0001 | -     | -   |
| - | 1890  | - | - | 0.17 | 2.68 | 1.24 | .0007 | .0141 | .0102 | .0039 | .13 | .0078 | .0001 | -     | 0.9 |
| - | 1891  | - | - | 0.17 | 2.30 | 0.94 | .0024 | .0143 | .0102 | .0041 | .11 | .0077 | .0001 | -     | 0.4 |
| - | 1892  | - | - | 0.20 | 2.52 | 1.03 | .0012 | .0142 | .0113 | .0029 | .12 | .0067 | .0000 | -     | 0.5 |
| - | 1893  | - | - | 0.35 | 2.45 | 0.93 | .0020 | .0182 | .0140 | .0042 | .14 | .0049 | .0000 | .3594 | 0.5 |

\* June to December.

NOTE to analyses of 1893; Iron, .0195. Odor, generally faintly vegetable, occasionally unpleasant, frequently none; on heating, the odor is much stronger and very frequently unpleasant. — The samples were collected from the reservoir near the gate-house, one foot beneath the surface.

## WORCESTER.

*Microscopical Examination of Water from the Tatnuck Brook Storage Reservoir.*

[Number of organisms per cubic centimeter.]

|                           | 1893.     |           |           |           |              |           |            |              |              |              |            |          |
|---------------------------|-----------|-----------|-----------|-----------|--------------|-----------|------------|--------------|--------------|--------------|------------|----------|
|                           | Jan.      | Feb.      | Mar.      | Apr.      | May.         | June.     | July.      | Aug.         | Sept.        | Oct.         | Nov.       | Dec.     |
| Day of examination, .     | 21        | 16        | 21        | 18        | 16           | 21        | 20         | 24           | 19           | 17           | 22         | 20       |
| Number of sample, .       | 9907      | 9999      | 10138     | 10258     | 10389        | 10532     | 10670      | 10873        | 11041        | 11201        | 11353      | 11513    |
| <b>PLANTS.</b>            |           |           |           |           |              |           |            |              |              |              |            |          |
| Diatomaceæ, . .           | 8         | 51        | 1         | 80        | 1,115        | 28        | 4          | 2,140        | 2,442        | 1,485        | 927        | 4        |
| Asterionella, . .         | 2         | 3         | 0         | 1         | 6            | 0         | 0          | 0            | 0            | 9            | 16         | 4        |
| Cyclotella, . .           | 0         | 0         | 0         | 3         | 0            | 0         | 0          | 40           | 3            | 3            | 0          | 0        |
| Melosira, . .             | 4         | 27        | 1         | 27        | 72           | 0         | 0          | 57           | 36           | 348          | 88         | 0        |
| Meridion, . .             | 0         | 0         | 0         | 28        | 1            | 0         | 0          | 0            | 0            | 0            | 1          | 0        |
| Navicula, . .             | 0         | 1         | pr.       | 0         | 0            | pr.       | 0          | 3            | 0            | 1            | 1          | 0        |
| Synedra, . .              | 0         | 8         | 0         | 4         | 36           | 0         | 0          | 0            | 3            | 0            | 1          | 0        |
| Tabellaria, . .           | 2         | 12        | 0         | 17        | 1,000        | 28        | 4          | 2,040        | 2,400        | 1,124        | 820        | 0        |
| Cyanophyceæ,              |           |           |           |           |              |           |            |              |              |              |            |          |
| Anabaena, . .             | 0         | 0         | 0         | 0         | 0            | 0         | 2          | 6            | 0            | 0            | 0          | 0        |
| Algae, . . . .            | 0         | 0         | 0         | pr.       | 6            | 0         | 102        | 224          | 30           | 61           | 63         | 0        |
| Chlorococcus, . .         | 0         | 0         | 0         | 0         | 0            | 0         | 2          | 0            | 26           | 52           | 6          | 0        |
| Gomphosphaeria, . .       | 0         | 0         | 0         | 0         | 0            | 0         | 0          | 0            | 0            | 0            | 0          | 0        |
| Pediastrum, . .           | 0         | 0         | 0         | 0         | 0            | 0         | 6          | 0            | 2            | 1            | 1          | 0        |
| Protococcus, . .          | 0         | 0         | 0         | 0         | 4            | 0         | 6          | 230          | 0            | 0            | 44         | 0        |
| Scenedesmus, . .          | 0         | 0         | 0         | pr.       | 1            | 0         | 32         | 2            | 1            | 6            | 6          | 0        |
| Staurostrum, . .          | 0         | 0         | 0         | 0         | 1            | 0         | 56         | 2            | 1            | 2            | 0          | 0        |
| Fungi, Crenothrix, .      | 0         | 1         | 0         | 0         | 0            | 2         | 0          | 0            | 0            | 3            | 0          | 0        |
| <b>ANIMALS.</b>           |           |           |           |           |              |           |            |              |              |              |            |          |
| Infusoria, . . .          | 10        | 7         | 1         | 5         | 64           | 1         | 2          | 6            | 17           | 11           | 0          | 1        |
| Ciliated Infusorian, .    | 0         | 0         | 0         | 0         | 0            | 0         | 0          | 0            | 0            | 2            | 0          | 0        |
| Dinobryon, . .            | 6         | 0         | 0         | 0         | 0            | 0         | 0          | 0            | 0            | 0            | 0          | 0        |
| Dinobryon cases, . .      | 4         | 7         | 0         | 0         | 30           | 0         | 0          | 0            | 1            | 1            | 0          | 0        |
| Encysted Protozoa, .      | 0         | 0         | 0         | 0         | 2            | 0         | 0          | 0            | 0            | 0            | 0          | 0        |
| Monas, . . . .            | 0         | 0         | 0         | 0         | 0            | 0         | 0          | 0            | 0            | 2            | 0          | 0        |
| Peridinium, . .           | 0         | 0         | 1         | 5         | 32           | 1         | 0          | 6            | 14           | 2            | 0          | 1        |
| Trachelomonas, . .        | 0         | 0         | 0         | 0         | 0            | 0         | 2          | 0            | 2            | 4            | 0          | 0        |
| Vermes, . . . .           | 8         | 0         | 0         | pr.       | pr.          | 0         | 1          | 0            | 5            | 0            | 1          | 0        |
| Anurea, . . . .           | 1         | 0         | 0         | 0         | 0            | 0         | 0          | 0            | 5            | 0            | 0          | 0        |
| Rotatorian ova, . .       | 0         | 0         | 0         | pr.       | 0            | 0         | 0          | 0            | 0            | 0            | 1          | 0        |
| Rotifer, . . . .          | 7         | 0         | 0         | 0         | 0            | 0         | 1          | 0            | 0            | 0            | 0          | 0        |
| Miscellaneous, Zoöglæa, . | 0         | 36        | 36        | 0         | 18           | 24        | 6          | 360          | 0            | 72           | 4          | 3        |
| <b>TOTAL, . . . .</b>     | <b>26</b> | <b>95</b> | <b>38</b> | <b>85</b> | <b>1,203</b> | <b>55</b> | <b>117</b> | <b>2,736</b> | <b>2,494</b> | <b>1,632</b> | <b>995</b> | <b>6</b> |

## WORCESTER.

*Chemical Examination of Water from Hermitage Pond, Worcester.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 10668   | 1893.<br>July 17    | Distinct.   | Cons.     | 0.08   | 5.25                    | 2.10              | .0094    | .0418       | .0268      | .0150      | .31       | .0030       | .0002     | .2886            | 2.1       |

Iron, .0125. Odor, faintly vegetable and unpleasant. — The sample was collected from the pond near the gate-house, one foot beneath the surface.

*Microscopical Examination.*

Diatomaceæ, *Asterionella*, 54; *Cyclotella*, 1; *Epithemia*, 1; *Fragilaria*, 6; *Melosira*, 216; *Synedra*, 104. Cyanophyceæ, *Clathrocystis*, 14. Algae, *Closterium*, 3; *Cosmarium*, 1; *Pediastrum*, 24; *Scenedesmus*, 8; *Staurostrum*, 144; *Zoospores*, 1 Infusoria, *Dinobryon*, 35; *Peridinium*, 3; *Vorticella*, 6. Vermes, *Anurea*, 1; *Polyarthra*, 1; *Rotatorian ova*, 2; *Rotifer*, 2. Crustacea, *Cyclops*, .01. Miscellaneous, *Zoëglæa*, 80. Total, 707.





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# EXAMINATION OF RIVERS.

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## EXAMINATION OF RIVERS.

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## EXAMINATION OF RIVERS.

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During the year 1893 regular monthly examinations were made of the waters of the Blackstone, Merrimack, Nashua (below Fitchburg), Neponset, Housatonic and Taunton rivers, and during the latter portion of the year, in connection with the investigations for a metropolitan water supply, of the Charles at South Natick, Deerfield, Nashua (above Clinton), and its tributaries, the Quinepoxet and Stillwater, Shawsheen and Ware rivers. A special examination has also been made of the tidal portion of the Charles River, which is a repetition of the examination of this stream made in 1893, and occasional examinations of other rivers in the State. Most of the results of these examinations will be found arranged alphabetically by rivers in the pages which follow; but some of them are given on preceding pages in connection with the examinations of water supplies, under the names of the towns where the samples were collected, as follows:—

|                                                                   | PAGE |
|-------------------------------------------------------------------|------|
| Town River (a tributary of the Taunton) at Bridgewater, . . . . . | 125  |
| Neponset River at Hyde Park, . . . . .                            | 177  |
| Merrimack River at Lawrence, . . . . .                            | 181  |
| Merrimack River at Lowell, . . . . .                              | 193  |
| Taunton River at Taunton, . . . . .                               | 296  |

### BLACKSTONE RIVER.

The character of the water of the Blackstone River is closely related to the disposal of the sewage of the city of Worcester, and it is therefore of interest to note that during 1893 the capacity of the precipitation works for treating the sewage of this city has been greatly increased by the construction of new precipitation tanks and other additions to the works, which were used for the first time on July 15. A full description of the works as originally constructed, and the results of a special examination of the works and the river during one week in 1891, can be found in the annual report of the State Board of Health for that year (pages 267-295).

**BLACKSTONE RIVER.**

Six precipitation tanks were constructed at first, and ten new tanks of the same area as the old ones were added in 1893. The new tanks, however, are longer and narrower than the others, their dimensions being 166.67 feet long, 40 feet wide and 5 feet deep below the bottom of the inlet and outlet channels. When in operation the tanks are filled to a depth of about six and a half feet, and with this depth they contain about 5,000,000 gallons of sewage.

For the information of those who are not familiar with the previous history of these works it may be stated that the sewage of Worcester is not taken directly from the sewers to the precipitation works, but is first discharged into Mill Brook; and it is the mingled sewage and brook water which is conveyed to the precipitation works and treated. Before the recent enlargement of the works only a small part of the flow of this brook could be treated, and the remainder of the sewage went directly into the Blackstone River; but the new works, which are said to have a nominal capacity of 15,000,000 gallons per day, and to be capable of treating with very good results a somewhat larger quantity, are thought to be of sufficient capacity to take the whole flow of the brook under all ordinary conditions.

The Worcester sewage is unusual in its character, both on account of its dilution by the brook water and because of the large amount of iron salts (mainly sulphate of iron) which it receives from time to time every working day from the large iron and wire works in the city. Lime has been the only precipitant added to the sewage in 1893, and when iron is present in the sewage a satisfactory precipitation results. The sewage, however, contains iron only a part of the time, and it is therefore the custom to store the sewage containing iron in two of the old precipitation tanks so that it can be used to mingle with the sewage subsequently arriving and containing no iron, and in this way form a satisfactory precipitate at all times.

Owing to the increase in the quantity of sewage treated it has been necessary to increase the capacity of the tanks in which the chemicals are mixed, and the old mixers have therefore been replaced by two new iron-lined mixers, each sixteen feet long, eight feet wide and three and a half feet deep. Lime is turned into the mixers from the floor above, and the mixture with water is accomplished by means of compressed air discharged through perforated pipes in the bottoms of the mixers. The lime mixture is conveyed

## BLACKSTONE RIVER.

through six-inch iron pipes to the sewer at a point ninety feet above the screens, instead of being discharged as formerly below the screens. This change was made in order to insure a more thorough mixing of the lime with the sewage previous to subsidence. The amount of lime necessary to make the sewage alkaline is determined by frequent tests with phenolphthalein.

The continuous process of precipitation is used, the sewage flowing through the different tanks in order, and the effluent being discharged continuously from the last one. The fall of the effluent is utilized, by means of a turbine wheel, to furnish power at night for lighting the works by electricity, and in the day time for pumping the sludge by means of a Shone ejector to sludge beds located near the Blackstone River. These beds at the present time cover an area of about fourteen acres. During 1893 nearly all of the sludge was disposed of to farmers for use as a fertilizer.

During the year ending Nov. 30, 1893, 1,795,000,000 gallons of sewage were treated and 1,105 tons of lime were used, making the amount of lime 1,232 pounds per million gallons of sewage. The amount of solid matter removed from the water during the year amounted to 2,360 tons.

The Worcester precipitation works have always been very intelligently operated under the direction of skilled chemists and engineers, and the following quotations from the annual report of the superintendent of sewers for the year ending Nov. 30, 1893, will be of interest as indicating the manner in which the work is carried on and the results obtained in the treatment of sewage since the works have been enlarged.

“From the first day the plant was operated, June 25, 1890, continued experiments have been made; at first, these were wholly mechanical and at random, but it was soon found that a systematic study of the whole problem must be made if the work was to be successful. Accordingly a well-equipped chemical laboratory has been provided and the problems met in actual manipulation are made subjects for special investigation. That this move has been productive of good is shown by the reduction of from thirty to fifty per cent. in the cost of chemicals used per million gallons of sewage treated.

Analyses of sewage and effluent are made daily. The samples for analysis are each composed of twenty-four portions taken hourly. Thus, by averaging results for several days, an effluent is obtained corresponding to



**BLACKSTONE RIVER.**

the sewage, and the per cent. of impurity removed is easily calculated. This per cent. removed is the indicator which shows the efficiency of the treatment.

Records of all analyses are kept in two forms; one simply the numerical tabulation, the other, a graphical illustration showing at a glance the constitution of the sewage and effluent, as well as the per cent. removed.

It will be noticed from accompanying table A, that the sewage dealt with is remarkably strong, considering that about half of it is water coming directly from North Pond. It is also interesting to note that the effluent contains only two and one-half parts per 100,000 of matter in suspension, and that, of this, only one and one-tenth parts are organic matter. Thus, by treatment, the organic suspended matter has been removed to the extent of 90.76 per cent. The total dissolved residue and the total and dissolved fixed residue are negative results, undoubtedly due to the large quantity of lime retained in solution in the effluent. From table A the result of the treatment of the sewage since July 15 can be followed by months, and the averages are given for the whole period."

"As the total volatile residue, the total albuminoid ammonia and the total oxygen consumed represent the amount of organic matter, these only are shown here :

|                                     |                          |
|-------------------------------------|--------------------------|
| Total volatile residue, . . . . .   | 51.06 per cent. removed. |
| Total albuminoid ammonia, . . . . . | 49.19 " " "              |
| Total oxygen consumed, . . . . .    | 33.27 " " "              |

The work done, as shown by these results, is very good, and should fully carry out the object of the plant, viz., not to transform sewage into a potable water, but to abate and finally terminate a nuisance to neighboring villages along the Blackstone River."

The results in 1893 are hardly as good as those obtained during the special examination for a week in 1891, but the difference is not very great, and the amount of chemicals used per million gallons during this year has been much less than during the week referred to.

The regular monthly examinations of the water of the Blackstone River have been continued as in previous years, and the results are given in the tables on pages 346-351. The first two tables contain, respectively, the results for each calendar year and for the six months of each year from June to November, from the time when the examinations were first begun in June, 1887, to the end of 1893.

TABLE A.  
WORCESTER SEWAGE PURIFICATION WORKS.\*  
*Analyses of Sewage and Effluent.*  
[Parts per 100,000.]

| DATE OF COLLECTION.                                                                  | RESIDUE ON EVAPORATION. |                       |                       |                       |                       |                      |                       |                       |                     |                        | AMMONIA.              |                       |                       | OXYGEN CONSUMED.      |                       | Chlorine.             |
|--------------------------------------------------------------------------------------|-------------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------------|-----------------------|-----------------------|---------------------|------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
|                                                                                      | TOTAL RESIDUE.          |                       |                       | VOLATILE RESIDUE.     |                       |                      | FIXED RESIDUE.        |                       |                     | Free.                  | ALUMINOID.            |                       | Unfiltered.           | Filtered.             |                       |                       |
|                                                                                      | Total.                  | Dissolved.            | Suspended.            | Total.                | Dissolved.            | Suspended.           | Total.                | Dissolved.            | Suspended.          |                        |                       |                       |                       |                       |                       |                       |
|                                                                                      |                         |                       |                       |                       |                       |                      |                       |                       |                     |                        |                       |                       |                       |                       |                       |                       |
| Sewage, July 19-31, 1893,<br>Effluent, July 19-31, 1893,<br>Per cent. removed, . . . | 70.2<br>89.2<br>16.07   | 48.0<br>66.0<br>16.07 | 22.2<br>23.2<br>85.69 | 32.1<br>16.0<br>80.16 | 17.9<br>13.5<br>24.69 | 14.2<br>2.5<br>82.39 | 38.1<br>43.2<br>13.59 | 30.1<br>42.5<br>41.20 | 8.0<br>0.7<br>91.23 | 1.043<br>3.66<br>6.71  | .622<br>.356<br>42.78 | .403<br>.239<br>40.60 | .219<br>.117<br>46.58 | 5.62<br>3.29<br>41.47 | 3.18<br>2.56<br>19.50 | 6.64<br>6.44<br>2.99  |
| Sewage, August, 1893,<br>Effluent, August, 1893,<br>Per cent. removed, . . .         | 61.2<br>53.9<br>11.92   | 40.9<br>50.7<br>19.33 | 20.3<br>3.2<br>84.24  | 30.7<br>14.9<br>51.47 | 18.6<br>13.5<br>27.42 | 12.1<br>1.8<br>88.43 | 30.5<br>39.0<br>27.87 | 22.3<br>37.2<br>66.82 | 8.2<br>1.8<br>78.05 | 1.137<br>1.083<br>4.75 | .558<br>.333<br>40.33 | .258<br>.261<br>2.32  | .300<br>.069<br>77.00 | 5.90<br>3.70<br>37.28 | 3.24<br>3.42<br>5.56  | 6.49<br>6.49<br>0.00  |
| Sewage, September, 1893,<br>Effluent, September, 1893,<br>Per cent. removed, . . .   | 62.1<br>54.0<br>13.04   | 43.4<br>61.7<br>19.13 | 18.7<br>2.3<br>87.70  | 29.3<br>14.6<br>60.17 | 17.0<br>13.5<br>20.59 | 12.3<br>1.1<br>91.05 | 32.8<br>38.2<br>20.12 | 26.4<br>38.2<br>44.70 | 6.4<br>1.2<br>81.25 | 1.488<br>1.426<br>4.17 | .522<br>.250<br>52.11 | .247<br>.204<br>17.42 | .275<br>.046<br>83.28 | 5.11<br>3.03<br>24.83 | 3.15<br>6.01<br>3.81  | 6.16<br>6.01<br>2.43  |
| Sewage, October, 1893,<br>Effluent, October, 1893,<br>Per cent. removed, . . .       | 67.7<br>54.0<br>20.21   | 46.4<br>61.6<br>11.20 | 21.3<br>2.4<br>88.74  | 28.7<br>19.8<br>53.65 | 16.6<br>12.5<br>24.70 | 12.1<br>0.8<br>93.40 | 39.0<br>40.7<br>4.36  | 29.8<br>39.1<br>31.21 | 9.2<br>1.6<br>82.60 | 1.584<br>1.604<br>6.05 | .576<br>.288<br>50.00 | .270<br>.214<br>33.30 | .297<br>.074<br>75.08 | 4.96<br>3.37<br>32.06 | 2.69<br>3.13<br>16.36 | 5.57<br>6.31<br>13.30 |
| Sewage, November, 1893,<br>Effluent, November, 1893,<br>Per cent. removed, . . .     | 57.5<br>51.4<br>10.09   | 41.7<br>50.0<br>19.91 | 15.8<br>1.4<br>91.11  | 22.8<br>12.1<br>46.93 | 13.1<br>11.5<br>12.21 | 9.7<br>0.6<br>93.80  | 34.6<br>39.3<br>13.58 | 28.6<br>38.5<br>34.61 | 6.0<br>0.8<br>86.07 | 1.548<br>1.465<br>5.39 | .450<br>.106<br>66.44 | .220<br>.155<br>29.54 | .230<br>.041<br>82.19 | 4.49<br>3.49<br>22.27 | 2.14<br>3.30<br>54.20 | 5.89<br>5.97<br>4.92  |

*Averages of Analyses July 19 to Dec. 1, 1893.*

|                          |       |       |       |       |       |       |       |       |      |       |       |       |       |       |       |      |
|--------------------------|-------|-------|-------|-------|-------|-------|-------|-------|------|-------|-------|-------|-------|-------|-------|------|
| Sewage, . . .            | 62.8  | 43.5  | 19.3  | 28.3  | 16.5  | 11.8  | 34.5  | 27.0  | 7.5  | 1.395 | .836  | .266  | .270  | 6.17  | 2.85  | 6.05 |
| Effluent, . . .          | 53.9  | 51.5  | 2.4   | 13.9  | 12.8  | 1.1   | 40.0  | 38.7  | 1.3  | 1.325 | .276  | .213  | .063  | 3.43  | 3.15  | 6.23 |
| Per cent. removed, . . . | 14.18 | 18.40 | 87.56 | 60.88 | 22.43 | 90.67 | 15.94 | 43.33 | 82.6 | 6.01  | 48.49 | 19.88 | 76.67 | 33.65 | 10.53 | 2.98 |

\* This table of analyses made at the Worcester Sewage Purification Works is taken from the annual report of the superintendent of sewers of Worcester for the year ending Nov. 30, 1893.

**BLACKSTONE RIVER.**

**AVERAGES OF CHEMICAL ANALYSES OF WATER FROM THE BLACKSTONE RIVER  
FOR THE YEARS 1888 TO 1893, INCLUSIVE.**

*Blackstone River between Mill Brook Channel and the Sewage Precipitation Works.*

[Parts per 100,000.]

| YEAR.           | Color. | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Hardness. |
|-----------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|-----------|
|                 |        | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |           |
|                 |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |           |
| 1888, . . . . . | 0.64   | -                               | -                    | .2112    | .1040       | -          | -               | 1.21      | .0370          | .0029     | -         |
| 1889, . . . . . | 0.76   | -                               | -                    | .2841    | .1198       | .0629      | .0569           | 1.06      | .0235          | .0024     | -         |
| 1890, . . . . . | 0.82   | -                               | -                    | .1800    | .1024       | .0549      | .0475           | 1.03      | .0367          | .0014     | -         |
| 1891, . . . . . | 0.80   | 13.54                           | 4.00                 | .3340    | .1563       | .0840      | .0723           | 1.78      | .0333          | .0032     | 4.6       |
| 1892, . . . . . | 0.71   | 16.28                           | 4.85                 | .2530    | .1262       | .0627      | .0635           | 1.84      | .0312          | .0061     | 4.9       |
| 1893, . . . . . | 0.68   | 17.95                           | 4.88                 | .1429    | .0603       | .0325      | .0277           | 1.04      | .0180          | .0012     | 4.5       |

*Blackstone River below Sewage Precipitation Works.*

|                 |      |       |      |       |       |       |       |      |       |       |     |
|-----------------|------|-------|------|-------|-------|-------|-------|------|-------|-------|-----|
| 1888, . . . . . | 0.64 | -     | -    | .2112 | .1040 | -     | -     | 1.21 | .0370 | .0029 | -   |
| 1889, . . . . . | 0.76 | -     | -    | .2841 | .1198 | .0629 | .0569 | 1.06 | .0235 | .0024 | -   |
| 1890, . . . . . | 0.74 | -     | -    | .2253 | .1177 | .0581 | .0596 | 1.26 | .0381 | .0016 | -   |
| 1891, . . . . . | 0.80 | 15.62 | 4.52 | .4080 | .1303 | .0696 | .0608 | 1.91 | .0358 | .0031 | 4.6 |
| 1892, . . . . . | 0.53 | 19.35 | 5.29 | .3633 | .1442 | .0737 | .0705 | 2.21 | .0278 | .0033 | 7.2 |
| 1893, . . . . . | 0.74 | 25.65 | 6.54 | .3757 | .1447 | .0864 | .0583 | 1.98 | .0369 | .0070 | 7.4 |

*Blackstone River at Uzbridge.*

|                 |      |      |      |       |       |       |       |      |       |       |     |
|-----------------|------|------|------|-------|-------|-------|-------|------|-------|-------|-----|
| 1888, . . . . . | 0.45 | -    | -    | .0979 | .0284 | -     | -     | 0.61 | .0322 | .0008 | -   |
| 1889, . . . . . | 0.28 | -    | -    | .0992 | .0300 | .0191 | .0109 | 0.60 | .0253 | .0009 | -   |
| 1890, . . . . . | 0.25 | -    | -    | .1168 | .0214 | .0152 | .0062 | 0.66 | .0272 | .0006 | -   |
| 1891, . . . . . | 0.27 | 8.32 | 1.94 | .1647 | .0272 | .0197 | .0075 | 0.77 | .0396 | .0008 | 2.8 |
| 1892, . . . . . | 0.21 | 8.60 | 1.90 | .2113 | .0222 | .0153 | .0069 | 0.82 | .0326 | .0007 | 2.8 |
| 1893, . . . . . | 0.40 | 9.45 | 1.91 | .1603 | .0256 | .0167 | .0089 | 1.00 | .0424 | .0029 | 3.2 |

*Blackstone River at Millville.*

|                 |      |      |      |       |       |       |       |      |       |       |     |
|-----------------|------|------|------|-------|-------|-------|-------|------|-------|-------|-----|
| 1888, . . . . . | 0.47 | -    | -    | .0444 | .0253 | -     | -     | 0.44 | .0242 | .0005 | -   |
| 1889, . . . . . | 0.38 | -    | -    | .0450 | .0277 | .0206 | .0071 | 0.43 | .0160 | .0004 | -   |
| 1890, . . . . . | 0.34 | -    | -    | .0587 | .0211 | .0162 | .0049 | 0.46 | .0240 | .0004 | -   |
| 1891, . . . . . | 0.32 | 6.05 | 1.83 | .0807 | .0293 | .0194 | .0099 | 0.55 | .0275 | .0005 | 1.9 |
| 1892, . . . . . | 0.35 | 6.03 | 1.62 | .0896 | .0249 | .0180 | .0069 | 0.54 | .0218 | .0004 | 1.8 |
| 1893, . . . . . | 0.40 | 6.23 | 1.53 | .0899 | .0288 | .0223 | .0063 | 0.66 | .0299 | .0008 | 2.0 |

## BLACKSTONE RIVER.

AVERAGES OF CHEMICAL ANALYSES OF WATER FROM THE BLACKSTONE RIVER FOR SIX MONTHS FROM JUNE TO NOVEMBER, INCLUSIVE, OF EACH YEAR FROM 1887 TO 1893.

*Blackstone River between Mill Brook Channel and the Sewage Precipitation Works.*

[Parts per 100,000.]

| MONTHS.                  | Color. | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Hardness. |
|--------------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|-----------|
|                          |        | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |           |
|                          |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |           |
| June-Nov., 1887, . . . . | 0.91   | -                               | -                    | .2686    | .1741       | -          | -               | 1.35      | .0160          | -         | -         |
| " " 1888, . . . .        | 0.76   | -                               | -                    | .2658    | .1112       | .0557      | .0555           | 1.50      | .0382          | .0041     | -         |
| " " 1889, . . . .        | 0.86   | -                               | -                    | .3980    | .1430       | .0772      | .0658           | 1.82      | .0177          | .0026     | -         |
| " " 1890, . . . .        | 1.14   | 9.92                            | 3.03                 | .2107    | .1246       | .0673      | .0573           | 1.07      | .0250          | .0015     | 2.9       |
| " " 1891, . . . .        | 1.10   | 17.42                           | 5.59                 | .4913    | .1950       | .1127      | .0823           | 2.29      | .0192          | .0037     | 5.0       |
| " " 1892, . . . .        | 0.52   | 20.75                           | 6.30                 | .3547    | .1433       | .0708      | .0725           | 2.43      | .0227          | .0108     | 6.1       |
| " " 1893, . . . .        | 0.40   | 16.98                           | 4.55                 | .1480    | .0588       | .0240      | .0348           | 1.01      | .0115          | .0015     | 6.3       |

*Blackstone River below Sewage Precipitation Works.*

|                        |      |       |      |       |       |       |       |      |       |       |      |
|------------------------|------|-------|------|-------|-------|-------|-------|------|-------|-------|------|
| June-Nov., 1887, . . . | 0.91 | -     | -    | .2686 | .1741 | -     | -     | 1.35 | .0160 | -     | -    |
| " " 1888, . . .        | 0.76 | -     | -    | .2658 | .1112 | .0557 | .0555 | 1.50 | .0382 | .0041 | -    |
| " " 1889, . . .        | 0.86 | -     | -    | .3980 | .1430 | .0772 | .0658 | 1.32 | .0177 | .0026 | -    |
| " " 1890, . . .        | 0.97 | 11.36 | 3.10 | .2907 | .1492 | .0722 | .0770 | 1.46 | .0270 | .0018 | 3.9  |
| " " 1891, . . .        | 1.05 | 22.25 | 6.60 | .6367 | .1508 | .0883 | .0625 | 2.61 | .0233 | .0040 | 6.2  |
| " " 1892, . . .        | 0.63 | 26.80 | 7.75 | .5240 | .1810 | .0958 | .0852 | 3.13 | .0137 | .0050 | 10.3 |
| " " 1893, . . .        | 0.51 | 30.00 | 7.13 | .5680 | .1453 | .0900 | .0553 | 2.76 | .0285 | .0126 | 10.9 |

*Blackstone River at Uxbridge.*

|                        |      |       |      |       |       |       |       |      |       |       |     |
|------------------------|------|-------|------|-------|-------|-------|-------|------|-------|-------|-----|
| June-Nov., 1887, . . . | 0.39 | -     | -    | .1129 | .0271 | -     | -     | 0.79 | .0360 | -     | -   |
| " " 1888, . . .        | 0.38 | 6.42  | 1.52 | .1155 | .0288 | .0222 | .0066 | 0.68 | .0310 | .0007 | -   |
| " " 1889, . . .        | 0.32 | -     | -    | .1133 | .0296 | .0192 | .0104 | 0.66 | .0333 | .0009 | -   |
| " " 1890, . . .        | 0.26 | 8.86  | 2.12 | .1029 | .0231 | .0174 | .0057 | 0.79 | .0259 | .0005 | 2.9 |
| " " 1891, . . .        | 0.20 | 10.16 | 2.61 | .2280 | .0175 | .0117 | .0058 | 1.04 | .0425 | .0007 | 3.6 |
| " " 1892, . . .        | 0.13 | 9.36  | 1.68 | .2840 | .0227 | .0162 | .0065 | 0.99 | .0313 | .0007 | 3.1 |
| " " 1893, . . .        | 0.24 | 11.74 | 2.37 | .1985 | .0207 | .0140 | .0067 | 1.20 | .0623 | .0050 | 4.2 |

*Blackstone River at Millville.*

|                        |      |      |      |       |       |       |       |      |       |       |     |
|------------------------|------|------|------|-------|-------|-------|-------|------|-------|-------|-----|
| June-Nov., 1887, . . . | 0.31 | -    | -    | .0468 | .0220 | -     | -     | 0.51 | .0210 | -     | -   |
| " " 1888, . . .        | 0.41 | 5.22 | 1.40 | .0467 | .0296 | .0233 | .0063 | 0.50 | .0278 | .0004 | -   |
| " " 1889, . . .        | 0.38 | -    | -    | .0499 | .0273 | .0213 | .0060 | 0.45 | .0167 | .0003 | -   |
| " " 1890, . . .        | 0.26 | 6.71 | 2.24 | .0736 | .0196 | .0152 | .0044 | 0.53 | .0229 | .0003 | 2.3 |
| " " 1891, . . .        | 0.24 | 7.48 | 2.35 | .1105 | .0384 | .0234 | .0150 | 0.72 | .0308 | .0006 | 2.2 |
| " " 1892, . . .        | 0.37 | 6.70 | 1.62 | .1143 | .0294 | .0210 | .0094 | 0.63 | .0217 | .0002 | 2.0 |
| " " 1893, . . .        | 0.23 | 7.43 | 1.73 | .0677 | .0119 | .0087 | .0031 | 0.77 | .0385 | .0011 | 2.6 |

## BLACKSTONE RIVER.

*Chemical Examination of Water from Blackstone River between*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                |        | RESIDUE ON EVAPORATION. |            |                 |                   |            |                 |
|---------|---------------------|------------------|----------------|--------|-------------------------|------------|-----------------|-------------------|------------|-----------------|
|         |                     | Turbidity.       | Sediment.      | Color. | TOTAL RESIDUE.          |            |                 | LOSS ON IGNITION. |            |                 |
|         |                     |                  |                |        | Total.                  | Dissolved. | Sus-<br>pended. | Total.            | Dissolved. | Sus-<br>pended. |
| 1893.   |                     |                  |                |        |                         |            |                 |                   |            |                 |
| 1       | 9926 Jan. 24        | Decided.         | Heavy, brown.  | 0.90   | 28.60                   | 22.50      | 6.10            | 9.90              | 6.10       | 3.80            |
| 2       | 10013 Feb. 14       | Decided.         | Heavy, gray.   | 0.50   | 16.20                   | 11.20      | 5.00            | 5.80              | 4.00       | 1.80            |
| 3       | 10123 Mar. 14       | Thick.           | Cons., gray.   | 0.40   | 37.80                   | 6.60       | 31.20           | 5.50              | 1.60       | 3.90            |
| 4       | 10263 April 18      | Decided, milky.  | Heavy, yellow. | 1.40   | 12.50                   | 9.00       | 3.50            | 5.30              | 3.30       | 2.00            |
| 5       | 10413 May 17        | Decided, milky.  | Heavy, gray.   | 1.30   | 9.80                    | 6.20       | 3.60            | 2.50              | 1.40       | 1.10            |
| 6       | 10538 June 20       | Decided.         | Heavy, brown.  | 0.30   | 22.70                   | 15.10      | 7.60            | 8.50              | 3.70       | 4.80            |
| 7       | 10676 July 18       | Decided.         | Heavy, brown.  | 1.80   | 18.50                   | -          | -               | 5.60              | -          | -               |
| 8       | 10870 Aug. 22       | Distinct, milky. | Heavy, iron.   | 0.10   | 10.60                   | -          | -               | 1.00              | -          | -               |
| 9       | 11052 Sept. 19      | Decided, milky.  | Cons., rusty.  | 0.15   | 15.80                   | 10.80      | 5.00            | 4.40              | 2.80       | 1.60            |
| 10      | 11212 Oct. 17       | Decided.         | Cons., rusty.  | 0.08   | 16.10                   | 15.10      | 1.00            | 3.60              | 3.30       | 0.30            |
| 11      | 11369 Nov. 21       | Decided.         | Cons.          | 0.04   | 18.20                   | 17.20      | 1.00            | 4.20              | 4.00       | 0.20            |
| 12      | 11524 Dec. 19       | Distinct.        | Slight, dark.  | 1.20   | 8.60                    | 7.90       | 0.70            | 2.30              | 2.30       | 0.00            |
| 13      | Av. ....            |                  |                | 0.68   | 17.95                   | -          | -               | 4.88              | -          | -               |

Odor, offensive. — The samples were collected from the river about 200 feet below the iron bridge. No. 10413 was collected on Wednesday and the remaining samples on Thursday. The first sample was collected at 12.45 P.M., and the remaining samples between 2.00 and 3.55 P.M.

*Chemical Examination of Water from Blackstone*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.     |                |        | RESIDUE ON EVAPORATION. |            |            |                   |            |            |
|---------|---------------------|-----------------|----------------|--------|-------------------------|------------|------------|-------------------|------------|------------|
|         |                     | Turbidity.      | Sediment.      | Color. | TOTAL RESIDUE.          |            |            | LOSS ON IGNITION. |            |            |
|         |                     |                 |                |        | Total.                  | Dissolved. | Suspended. | Total.            | Dissolved. | Suspended. |
| 1893.   |                     |                 |                |        |                         |            |            |                   |            |            |
| 1       | 9927 Jan. 24        | Decided.        | Heavy, brown.  | 0.65   | 33.80                   | 26.50      | 7.30       | 11.20             | 7.10       | 4.10       |
| 2       | 10014 Feb. 14       | Decided.        | Heavy, gray.   | 0.70   | 16.40                   | 13.80      | 2.60       | 6.00              | 4.00       | 2.00       |
| 3       | 10124 Mar. 14       | Thick.          | Cons., gray.   | 0.50   | 38.30                   | 6.80       | 31.50      | 7.20              | 1.80       | 5.40       |
| 4       | 10264 April 18      | Decided, milky. | Heavy, yellow. | 1.40   | 13.70                   | 9.20       | 4.50       | 5.50              | 3.00       | 2.50       |
| 5       | 10414 May 17        | Decided, milky. | Heavy, gray.   | 1.40   | 10.00                   | 6.00       | 4.00       | 2.10              | 1.50       | 0.60       |
| 6       | 10539 June 20       | Decided.        | Heavy.         | 1.00   | 24.00                   | 14.60      | 9.40       | 9.40              | 3.70       | 5.70       |
| 7       | 10677 July 18       | Decided.        | Heavy, brown.  | 1.00   | 30.90                   | -          | -          | 5.70              | -          | -          |
| 8       | 10871 Aug. 22       | Decided, milky. | Cons. dark.    | 0.40   | 16.60                   | -          | -          | 3.30              | -          | -          |
| 9       | 11053 Sept. 19      | Thick, milky.   | Heavy, rusty.  | 0.40   | 34.80                   | 29.00      | 5.80       | 8.60              | 6.80       | 1.80       |
| 10      | 11213 Oct. 17       | Distinct.       | Cons., rusty.  | 0.18   | 44.50                   | 43.50      | 1.00       | 8.90              | 8.30       | 0.60       |
| 11      | 11370 Nov. 21       | Decided.        | Heavy, rusty.  | 0.10   | 29.20                   | 24.80      | 4.40       | 6.40              | 5.00       | 1.40       |
| 12      | 11525 Dec. 19       | Distinct.       | Slight, rusty. | 1.10   | 15.60                   | 12.80      | 2.80       | 3.70              | 3.50       | 0.20       |
| 13      | Av. ....            |                 |                | 0.74   | 25.65                   | -          | -          | 6.54              | -          | -          |

Odor, offensive. — The samples were collected from the river above Millbury and below the point where the effluent from the Worcester Precipitation Works enters the river. No. 10414 was collected on Wednesday and the remaining samples on Thursday. The samples were collected between 1.00 and 3.10 P.M.

## BLACKSTONE RIVER.

*Mill Brook Channel and the Worcester Sewage Precipitation Works.*

[Parts per 100,000.]

| AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | IRON        |           | Hardness. |    |
|----------|-------------|------------|------------|-----------|-------------|-----------|-------------|-----------|-----------|----|
| Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. | Unfiltered. | Filtered. |           |    |
|          | Total.      | Dissolved. | Suspended. |           |             |           |             |           |           |    |
| .3840    | .2820       | .1960      | .0860      | 2.28      | .0070       | .0007     | 4.4000      | 3.4000    | 7.0       | 1  |
| .2080    | .1260       | .0820      | .0440      | 1.34      | .0300       | .0011     | .3440       | .2200     | 1.4       | 2  |
| .0800    | .0820       | .0540      | .0280      | 1.00      | .0200       | .0012     | .5400       | .1300     | 1.9       | 3  |
| .0510    | .0580       | .0330      | .0250      | .74       | .0250       | .0020     | .3000       | .2100     | 2.2       | 4  |
| .0520    | .0400       | .0280      | .0120      | .33       | .0400       | .0007     | .0340       | .0200     | 1.5       | 5  |
| .2800    | .2040       | .0600      | .1440      | 2.16      | .0300       | .0050     | 1.7000      | .7400     | 5.1       | 6  |
| .0800    | .0450       | .0240      | .0210      | .76       | .0000       | .0000     | 4.6000      | -         | 9.7       | 7  |
| .0580    | .0240       | .0130      | .0110      | .79       | .0300       | .0012     | .6000       | -         | 3.9       | 8  |
| .2560    | .0540       | .0320      | .0220      | .90       | .0090       | .0014     | .8000       | .1000     | 3.7       | 9  |
| .1680    | .0110       | .0090      | .0020      | .85       | .0000       | .0009     | 3.1000      | 1.0400    | 6.0       | 10 |
| .0480    | .0150       | .0060      | .0090      | .60       | .0000       | .0005     | 1.3200      | .9400     | 9.6       | 11 |
| .0520    | .0360       | .0300      | .0060      | .70       | .0250       | .0003     | .3500       | .1800     | 1.9       | 12 |
| .1429    | .0814       | .0472      | .0342      | 1.04      | .0180       | .0012     | 1.5073      | .5842     | 4.5       | 13 |

*Microscopical Examination.*

Nos. 10123 and 10263 were not examined. The remaining samples contained Zoöglæa, generally in very large numbers, and only a few of other organisms.

*River below the Worcester Sewage Precipitation Works.*

[Parts per 100,000.]

| AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | IRON.       |           | Hardness. |    |
|----------|-------------|------------|------------|-----------|-------------|-----------|-------------|-----------|-----------|----|
| Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. | Unfiltered. | Filtered. |           |    |
|          | Total.      | Dissolved. | Suspended. |           |             |           |             |           |           |    |
| .4060    | .4800       | .2420      | .2180      | 2.40      | .0070       | .0009     | 4.9000      | 3.6000    | 10.1      | 1  |
| .2160    | .1400       | .0820      | .0580      | 1.60      | .0400       | .0015     | .4700       | .3000     | 3.5       | 2  |
| .0880    | .1020       | .0560      | .0460      | 0.98      | .0220       | .0010     | .5200       | .1240     | 2.5       | 3  |
| .0450    | .0480       | .0300      | .0180      | 0.77      | .1000       | .0020     | .7000       | .2000     | 1.8       | 4  |
| .0160    | .0480       | .0280      | .0200      | 0.34      | .0400       | .0007     | .0390       | .0200     | 1.5       | 5  |
| .2960    | .2640       | .0940      | .1700      | 2.52      | .0070       | .0001     | 1.3500      | .4400     | 3.6       | 6  |
| .2000    | .0620       | .0290      | .0380      | 2.17      | .0000       | .0000     | 3.9000      | -         | 16.6      | 7  |
| .2320    | .0780       | .0300      | .0390      | 1.54      | .0150       | .0100     | .0500       | -         | 5.7       | 8  |
| .9600    | .2200       | .1600      | .0600      | 3.84      | .0050       | .0512     | .7600       | .1500     | 11.9      | 9  |
| .9000    | .1070       | .1500      | .0080      | 4.44      | .0750       | .0035     | .2950       | .0100     | 16.1      | 10 |
| .7000    | .0810       | .0590      | .0220      | 2.02      | .0690       | .0060     | .6000       | .0080     | 11.2      | 11 |
| .2000    | .0670       | .0590      | .0080      | 1.15      | .0030       | .0018     | .3800       | .2800     | 4.6       | 12 |
| .3757    | .1447       | .0864      | .0583      | 1.98      | .0369       | .0070     | 1.1637      | .5132     | 7.4       | 13 |

*Microscopical Examination.*

Nos. 10124 and 10264 were not examined. The remaining samples contained Zoöglæa often in very large numbers, and only a few of other organisms.

**BLACKSTONE RIVER.***Chemical Examination of Water from Blackstone River at Uxbridge.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |              |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|------------------|--------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.       | Sediment.    | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                  |              |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 9899    | 1893.<br>Jan. 19    | Distinct, milky. | Slight.      | 0.05   | 9.10                    | 1.80              | .1920    | .0210       | .0160      | .0050      | 1.20      | .0100       | .0015     | .2525            | 2.7       |
| 10026   | Feb. 16             | Distinct, milky. | Slight.      | 0.75   | 5.70                    | 0.85              | .0800    | .0410       | .0180      | .0230      | 0.70      | .0250       | .0003     | .4822            | 1.9       |
| 10131   | Mar. 16             | Decided, milky.  | Cons. gray.  | 0.50   | 4.80                    | 1.60              | .0520    | .0370       | .0270      | .0100      | 0.80      | .0180       | .0001     | .4906            | 1.1       |
| 10281   | Apr. 20             | Decided, milky.  | Slight.      | 0.90   | 5.20                    | 1.15              | .0720    | .0260       | .0160      | .0100      | 0.46      | .0350       | .0007     | .3540            | 1.7       |
| 10415   | May 18              | Distinct, milky. | Cons. rusty. | 0.65   | 5.90                    | 1.10              | .0760    | .0300       | .0180      | .0120      | 0.43      | .0250       | .0010     | .3212            | 1.4       |
| 10549   | June 23             | Distinct.        | Cons.        | 0.20   | 8.50                    | 1.90              | .2080    | .0280       | .0210      | .0070      | 0.86      | .0350       | .0010     | .2291            | 2.2       |
| 10691   | July 20             | Slight, milky.   | Slight.      | 0.03   | 9.50                    | 2.00              | .2350    | .0140       | .0090      | .0050      | 1.00      | .0070       | .0002     | .1534            | 2.8       |
| 10885   | Aug. 24             | Distinct, milky. | Cons.        | 0.40   | 11.80                   | 3.40              | .1880    | .0170       | .0110      | .0060      | 1.23      | .0600       | .0056     | .4700            | 3.9       |
| 11067   | Sept. 21            | Distinct.        | Slight.      | 0.30   | 11.95                   | 2.15              | .0600    | .0250       | .0150      | .0100      | 1.22      | .1200       | .0170     | .3280            | 4.7       |
| 11227   | Oct. 19             | Decided.         | Cons.        | 0.18   | 15.90                   | 2.85              | .2000    | .0220       | .0140      | .0080      | 1.04      | .1100       | .0050     | .2508            | 6.3       |
| 11375   | Nov. 23             | Decided.         | V. slight.   | 0.30   | 12.80                   | 1.90              | .3000    | .0180       | .0140      | .0040      | 1.27      | .0420       | .0010     | .2226            | 5.4       |
| 11639   | Dec. 21             | Distinct, milky. | V. slight.   | 0.50   | .30                     | 2.20              | .2600    | .0280       | .0210      | .0070      | 1.19      | .0220       | .0009     | .5467            | 4.0       |
| Av.     | .....               | .....            | .....        | 0.40   | 9.45                    | 1.91              | .1603    | .0256       | .0167      | .0089      | 1.00      | .0424       | .0029     | .3419            | 3.2       |

Iron, .0474. Odor, generally musty, occasionally disagreeable or offensive. — The samples were collected from the canal leading from the upper dam of the Calumet Woolen Company to the mill just before the water passed the screens.

*Microscopical Examination.*

The number of organisms found in these samples varied from 143 to 3,360 per cubic centimeter and averaged 787, Zoöglæa being by far the most abundant and averaging 724.

## BLACKSTONE RIVER.

*Chemical Examination of Water from Blackstone River at Millville, Blackstone.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.          |                    |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|----------------------|--------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.           | Sediment.          | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                      |                    |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 9906    | 1893.<br>Jan. 19    | Slight,<br>milky.    | Slight.            | 0.50   | 6.05                            | 1.40                 | .0594    | .0280       | .0246      | .0034           | .43       | .0280          | .0003     | .3869            | 1.9       |
| 10031   | Feb. 16             | Distinct,<br>clayey. | Slight,<br>earthy. | 0.60   | 4.20                            | 1.40                 | .0400    | .0180       | .0150      | .0030           | .33       | .0180          | .0001     | .4710            | 1.1       |
| 10134   | Mar. 16             | Distinct,<br>milky.  | Cons.,<br>gray.    | 0.50   | 3.35                            | 1.05                 | .0250    | .0130       | .0050      | .0080           | 1.04      | .0100          | .0004     | .3996            | 0.9       |
| 10283   | Apr. 20             | Distinct,<br>milky.  | Slight.            | 0.65   | 4.30                            | 1.15                 | .2200    | .0920       | .0720      | .0200           | .36       | .0200          | .0005     | .3869            | 1.1       |
| 10419   | May 18              | Distinct,<br>milky.  | Cons.,<br>rusty.   | 0.65   | 4.60                            | 1.70                 | .1920    | .0930       | .0760      | .0170           | .30       | .0150          | .0005     | .4124            | 1.1       |
| 10558   | June 23             | Distinct,<br>milky.  | Slight.            | 0.55   | 5.10                            | 1.45                 | .0760    | .0100       | .0050      | .0050           | .46       | .0050          | .0003     | .2765            | 1.5       |
| 10689   | July 20             | Distinct,<br>milky.  | Cons.              | 0.05   | 7.55                            | 1.50                 | .1930    | .0170       | .0140      | .0030           | .88       | .0200          | .0002     | .1924            | 2.5       |
| 10887   | Aug. 24             | Slight.              | Slight,<br>rusty.  | 0.28   | 8.70                            | 2.70                 | .0174    | .0044       | .0032      | .0012           | .97       | .0500          | .0010     | .3531            | 2.6       |
| 11074   | Sept. 21            | Slight.              | Cons.,<br>brown.   | 0.18   | 8.75                            | 1.95                 | .0160    | .0228       | .0192      | .0036           | .88       | .0700          | .0028     | .3239            | 3.1       |
| 11230   | Oct. 19             | Distinct,<br>milky.  | Slight.            | 0.20   | 8.35                            | 1.05                 | .0230    | .0100       | .0070      | .0030           | .82       | .0580          | .0017     | .3230            | 3.0       |
| 11381   | Nov. 23             | Distinct.            | Slight.            | 0.30   | 6.10                            | 1.15                 | .0760    | .0070       | .0040      | .0030           | .60       | .0280          | .0006     | .1512            | 2.6       |
| 11538   | Dec. 21             | Distinct,<br>milky   | Slight.            | 0.50   | 7.70                            | 1.30                 | .1360    | .0300       | .0250      | .0050           | .83       | .0250          | .0007     | .5265            | 2.3       |
| Av.     | .....               | .....                | .....              | 0.40   | 6.23                            | 1.53                 | .0899    | .0288       | .0225      | .0063           | 0.66      | .0280          | .0008     | .3503            | 2.0       |

Iron, .0452. Odor, generally musty, frequently disagreeable or offensive. — The samples were collected from the river just above the dam in the village of Millville.

*Microscopical Examination.*

The number of organisms found in these samples varied from 107 to 946 per cubic centimeter and averaged 294, Zoöglea being in most cases by far the most abundant and averaging 224.

CHARLES RIVER.

Regular monthly examinations of the water of Charles River above South Natick have been made during the last five months of 1893, and weekly examinations of the water at Ætna Mills and at a point about 2,000 feet below Galen Street bridge in Watertown were made from August 17 to October 26. An examination of the whole length of the tidal portion of the river by means of a series of chemical analyses of its water at high and low tide was made on August 17, 1893, during a course of neap tides occurring at a time when the flow of upland water was small. This examination of the tidal portion of the river is a repetition of a similar examination made in 1892, and fully described in the annual report of the State Board of Health for that year (pp. 282-289). Results of all of the analyses made during 1893 are given in the following tables: —



## CHARLES RIVER.

*Chemical Examination of Water from the Charles River at South Natick.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1893.   |                     |             |            |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 10881   | Aug. 23             | None.       | V. slight. | 0.60   | 5.00                    | 2.05              | .0000    | .0182       | .0134      | .0048      | .43       | .0030       | .0000     | .6162            | 1.1       |
| 11089   | Sept. 25            | V. slight.  | V. slight. | 0.55   | 4.75                    | 1.75              | .0000    | .0242       | .0226      | .0016      | .47       | .0050       | .0000     | .6150            | 1.7       |
| 11242   | Oct. 23             | V. slight.  | Slight.    | 0.00   | 5.30                    | 1.80              | .0002    | .0226       | .0158      | .0068      | .52       | .0030       | .0000     | .4940            | 1.7       |
| 11398   | Nov. 27             | V. slight.  | Slight.    | 0.70   | 5.60                    | 2.25              | .0006    | .0194       | .0156      | .0038      | .52       | .0090       | .0001     | .8901            | 1.7       |
| 11559   | Dec. 27             | V. slight.  | V. slight. | 0.80   | 5.10                    | 2.35              | .0004    | .0156       | .0134      | .0022      | .38       | .0150       | .0001     | .8932            | 1.1       |
| Av.     | .....               | .....       | .....      | 0.65   | 5.15                    | 2.04              | .0002    | .0200       | .0162      | .0038      | .46       | .0070       | .0000     | .7017            | 1.5       |

Iron, .0204. Odor, generally distinctly vegetable, and in the first two samples also mouldy; in the second sample the odor was disagreeable. — The samples were collected from the river above the dam at South Natick.

*Microscopical Examination.*

Average number of organisms, 59 per cubic centimeter.

*Chemical Examination of Water from the Charles River at Aetna Mills, Watertown.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |                    |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------------|--------------------|--------|---------------------------------|----------------------|----------|-------------|------------|----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.        | Sediment.          | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                   |                    |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended |           |                |           |                  |           |
| 1893.   |                     |                   |                    |        |                                 |                      |          |             |            |                |           |                |           |                  |           |
| 10820   | Aug. 17             | Slight.           | Slight,<br>earthy. | 0.70   | -                               | -                    | .0048    | .0222       | .0206      | .0016          | .60       | .0200          | .0002     | .5648            | -         |
| 10849   | Aug. 17             | Slight.           | Slight.            | 0.70   | -                               | -                    | .0086    | .0252       | .0236      | .0016          | .58       | .0250          | .0002     | .6802            | -         |
| 10892   | Aug. 25             | Slight.           | Cons.,<br>brown.   | 0.60   | 7.05                            | 2.05                 | .0106    | .0226       | .0196      | .0030          | .72       | .0300          | .0010     | .5617            | 2.1       |
| 10949   | Aug. 31             | Slight.           | Slight.            | 0.65   | 5.90                            | 1.90                 | .0066    | .0212       | .0190      | .0022          | .58       | .0350          | .0006     | .5411            | 1.9       |
| 10992   | Sept. 7             | Slight,<br>green. | Slight,<br>yellow. | 0.65   | 6.10                            | 1.80                 | .0086    | .0230       | .0202      | .0028          | .59       | .0180          | .0007     | .5538            | 2.1       |
| 11028   | Sept. 14            | Slight.           | Slight,<br>rusty.  | 0.50   | 7.35                            | 2.80                 | .0006    | .0362       | .0230      | .0132          | .80       | .0200          | .0010     | .6318            | 2.6       |
| 11078   | Sept. 21            | Slight,<br>green. | Slight.            | 0.60   | 5.90                            | 1.75                 | .0120    | .0222       | .0196      | .0026          | .66       | .0100          | .0005     | .5494            | 2.4       |
| 11119   | Sept. 29            | Distinct.         | Cons.,<br>green.   | 0.60   | 7.80                            | 2.30                 | .0012    | .0310       | .0234      | .0076          | .81       | .0180          | .0008     | .7276            | 3.0       |
| 11151   | Oct. 5              | Distinct.         | Cons.,<br>gray.    | 0.48   | 6.90                            | 1.80                 | .0062    | .0196       | .0150      | .0046          | .72       | .0250          | .0005     | .4466            | 2.3       |
| 11197   | Oct. 13             | Slight.           | Cons.              | 0.32   | 6.80                            | 2.00                 | .0036    | .0254       | .0222      | .0032          | .66       | .0200          | .0002     | .4495            | 2.3       |
| 11231   | Oct. 19             | Slight.           | Slight.            | 0.50   | 7.40                            | 1.80                 | .0148    | .0220       | .0176      | .0044          | .71       | .0250          | .0007     | .4332            | 2.3       |
| 11284   | Oct. 26             | Slight.           | Cons.,<br>fibrous. | 0.53   | 9.45                            | 2.05                 | .0158    | .0218       | .0190      | .0028          | .99       | .0450          | .0013     | .4712            | 3.1       |
| Av.     | .....               | .....             | .....              | 0.57   | 7.02                            | 2.03                 | .0083    | .0244       | .0202      | .0042          | .70       | .0242          | .0006     | .5509            | 2.4       |

Iron, .0214. Odor, decidedly vegetable and musty or mouldy. — The samples were collected from the canal at the Aetna Mills.

## CHARLES RIVER.

*Microscopical Examination of Water from the Charles River at Ætna Mills, Watertown.*

[Number of organisms per cubic centimeter.]

|                           | 1893. |       |       |       |       |       |       |       |       |       |       |       |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                           | Aug.  | Aug.  | Aug.  | Sept. | Sept. | Sept. | Sept. | Oct.  | Oct.  | Oct.  | Oct.  | Oct.  |
| Day of examination, .     | -     | -     | 29    | 2     | 9     | 16    | 23    | 2     | 7     | 16    | 21    | 27    |
| Number of sample, .       | 10820 | 10849 | 10892 | 10949 | 10992 | 11028 | 11078 | 11119 | 11151 | 11197 | 11231 | 11254 |
| PLANTS.                   |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . .           | -     | -     | 1     | 7     | 8     | 1     | 3     | 0     | 10    | 6     | 4     | 9     |
| Asterionella, . .         | -     | -     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 5     | 0     | 2     |
| Cyclotella, . .           | -     | -     | 0     | 0     | 5     | 0     | 0     | 0     | 0     | 0     | 1     | 2     |
| Navicula, . .             | -     | -     | 1     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 4     |
| Synedra, . .              | -     | -     | 0     | 5     | 1     | 1     | 3     | 0     | 2     | 1     | 1     | 1     |
| Tabellaria, . .           | -     | -     | 0     | 0     | 0     | 0     | 0     | 0     | 8     | 0     | 1     | 0     |
| Algæ, Protococcus, .      | -     | -     | 20    | 4     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Fungi, . . . .            | -     | -     | 200   | 200   | 36    | 1,400 | 108   | 249   | 92    | 120   | 36    | 11    |
| Crenothrix, . .           | -     | -     | 200   | 200   | 36    | 1,400 | 108   | 249   | 92    | 120   | 30    | 11    |
| Molds, . . . .            | -     | -     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 6     | 0     |
| ANIMALS.                  |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . . .        | -     | -     | 3     | 1     | 0     | 1     | 0     | 0     | 0     | 3     | 0     | 1     |
| Monas, . . . .            | -     | -     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 1     |
| Peridinium, . .           | -     | -     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 1     | 0     | 0     |
| Trachelomonas, .          | -     | -     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Miscellaneous, Zoöglæa, . | -     | -     | 204   | 76    | 36    | 40    | 24    | 48    | 140   | 48    | 10    | 48    |
| TOTAL, . . . .            | -     | -     | 428   | 288   | 78    | 1,442 | 135   | 297   | 242   | 177   | 50    | 69    |

**CHARLES RIVER.**

*Chemical Examination of Water from Charles River about Two Thousand Feet below Galen Street Bridge, Watertown.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |       | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|-------------|-----------|-------------|-------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.       | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |             |           |             |       |                  |           |
|         |                     |             |                 |        |                         |                   |          | Total.      | Dissolved. | Sus-pended. |           |             |       |                  |           |
| 10821   | Aug 17              | Distinct.   | Cons., flocc't. | 0.75   | -                       | -                 | .0024    | .0320       | .0266      | .0054       | 0.87      | .0100       | .0002 | 1.0191           | -         |
| 10850   | Aug.17              | Distinct.   | Cons., fibrous. | 0.70   | -                       | -                 | .0008    | .0328       | .0278      | .0050       | 1.58      | .0200       | .0004 | .7488            | -         |
| 10893   | Aug.25              | Slight.     | Cons., brown.   | 0.70   | 7.20                    | 2.15              | .0052    | .0284       | .0226      | .0058       | 0.73      | .0200       | .0008 | .6478            | 2.2       |
| 10950   | Aug.31              | Distinct.   | Cons., brown.   | 0.60   | 6.80                    | 2.60              | .0048    | .0246       | .0212      | .0034       | 0.94      | .0150       | .0004 | .5451            | 1.9       |
| 10993   | Sept. 7             | Slight.     | Slight.         | 0.90   | 7.70                    | 3.10              | .0006    | .0274       | .0226      | .0048       | 0.68      | .0250       | .0009 | .6240            | 2.5       |
| 11029   | Sept.14             | Distinct.   | Cons., dark.    | 0.68   | 13.00                   | 4.05              | .0008    | .0414       | .0274      | .0140       | 1.80      | .0120       | .0009 | .6435            | 4.1       |
| 11079   | Sept.21             | Distinct.   | Cons., fibrous. | 0.60   | 8.15                    | 2.40              | .0000    | .0304       | .0258      | .0046       | 0.80      | .0100       | .0005 | .6970            | 3.1       |
| 11120   | Sept.29             | V. slight.  | Heavy, gray.    | 0.63   | 8.40                    | 2.20              | .0020    | .0228       | .0204      | .0024       | 1.66      | .0200       | .0003 | .4851            | 2.6       |
| 11132   | Oct. 5              | Decided     | Heavy, gray.    | 0.45   | 9.50                    | 2.40              | .0000    | .0392       | .0224      | .0168       | 1.19      | .0150       | .0007 | .5775            | 2.8       |
| 11198   | Oct. 13             | Decided.    | Cons., gray.    | 0.55   | 13.30                   | 3.25              | .0016    | .0378       | .0236      | .0142       | 2.81      | .0100       | .0007 | .7533            | 4.7       |
| 11232   | Oct. 19             | Distinct.   | Cons., gray.    | 0.55   | 12.10                   | 2.00              | .0042    | .0364       | .0276      | .0088       | 1.96      | .0300       | .0013 | .8056            | 4.2       |
| 11255   | Oct. 26             | Slight.     | Cons., gray.    | 0.48   | 12.70                   | 2.10              | .0068    | .0330       | .0240      | .0090       | 2.46      | .0290       | .0018 | .5396            | 3.8       |
| Av..    | .....               | .....       | .....           | 0.63   | 9.89                    | 2.63              | .0024    | .0322       | .0243      | .0079       | 1.46      | .0180       | .0007 | .6739            | 3.2       |

Iron, .0313. Odor, decidedly vegetable and musty or mouldy. — The samples were collected from the river about 2,000 feet below Galen Street bridge in Watertown, and about 400 feet below Barker's Starch Works. The point at which the samples were collected is in the tidal portion of the river, but it is doubtful if any salt water ever flows up to this point.

*Microscopical Examination of Water from Charles River about Two Thousand Feet below Galen Street Bridge, Watertown.*

[Number of organisms per cubic centimeter.]

|                                     | 1893. |       |       |       |       |       |       |       |       |       |       |       |
|-------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                     | Aug.  | Aug.  | Aug.  | Sept. | Sept. | Sept. | Sept. | Oct.  | Oct.  | Oct.  | Oct.  | Oct.  |
| Day of examination, . . .           | -     | -     | 29    | 2     | 9     | 16    | 22    | 2     | 7     | 16    | 21    | 27    |
| Number of sample, . . .             | 10821 | 10850 | 10893 | 10950 | 10993 | 11029 | 11079 | 11120 | 11152 | 11198 | 11232 | 11255 |
| PLANTS.                             |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .                   | -     | -     | 0     | 7     | 3     | 9     | 3     | 0     | 8     | 0     | 8     | 25    |
| Navicula, . . .                     | -     | -     | 0     | 2     | 1     | 1     | 0     | 0     | 0     | 0     | 2     | 1     |
| Synedra, . . .                      | -     | -     | 0     | 5     | 2     | 8     | 3     | 0     | 8     | 0     | 6     | 24    |
| Cyanophyceæ, Oscil-<br>laria, . . . | -     | -     | 1     | 8     | 0     | 20    | 1     | 4     | 0     | 0     | 0     | 9     |
| Algæ, Chlorococcus, . .             | -     | -     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 4     | 0     | 0     |

## CHARLES RIVER.

*Microscopical Examination of Water from Charles River, etc. — Concluded.*

[Number of organisms per cubic centimeter.]

|                           | 1893. |      |      |       |       |       |       |      |      |      |      |      |
|---------------------------|-------|------|------|-------|-------|-------|-------|------|------|------|------|------|
|                           | Aug.  | Aug. | Aug. | Sept. | Sept. | Sept. | Sept. | Oct. | Oct. | Oct. | Oct. | Oct. |
| PLANTS — Con.             |       |      |      |       |       |       |       |      |      |      |      |      |
| Fungi, . . . . .          | -     | -    | 44   | 132   | 180   | 82    | 4     | 118  | 172  | 50   | 27   | 128  |
| Beggiatoa, . . . .        | -     | -    | 0    | 0     | 0     | 2     | 0     | 0    | 0    | 0    | 1    | 32   |
| Crenothrix, . . . .       | -     | -    | 44   | 132   | 180   | 80    | 4     | 118  | 172  | 50   | 26   | 96   |
| ANIMALS.                  |       |      |      |       |       |       |       |      |      |      |      |      |
| Infusoria, . . . .        | -     | -    | 0    | 4     | 3     | 1     | 3     | 0    | 3    | 6    | 1    | 1    |
| Monas, . . . . .          | -     | -    | 0    | 0     | 1     | 1     | 3     | 0    | 0    | 4    | 0    | 1    |
| Paramacium, . . .         | -     | -    | 0    | 0     | 0     | 0     | 0     | 0    | 3    | 2    | 0    | 0    |
| Peridinium, . . .         | -     | -    | 0    | 4     | 0     | 0     | 0     | 0    | 0    | 0    | 1    | 0    |
| Trachelomonas, . .        | -     | -    | 0    | 0     | 2     | 0     | 0     | 0    | 0    | 0    | 0    | 0    |
| Miscellaneous, Zoöglæa, . | -     | -    | 108  | 104   | 56    | 64    | 400   | 152  | 192  | 808  | 260  | 440  |
| TOTAL, . . . . .          | -     | -    | 153  | 255   | 242   | 176   | 411   | 274  | 376  | 868  | 296  | 603  |

*Chemical Examination of Water from the Tidal Portion of Charles River at Various Points, during High Water of Neap Tides, Aug. 17, 1893.*

[Parts per 100,000.]

| Number. | LOCALITY.            | APPEARANCE. |                 |        | ODOR.             |                     | AMMONIA.    |        |            |            | Chlorine. | Nitrogen as Nitrites. | Oxygen Consumed. |
|---------|----------------------|-------------|-----------------|--------|-------------------|---------------------|-------------|--------|------------|------------|-----------|-----------------------|------------------|
|         |                      | Turbidity.  | Sediment.       | Color. | Cold.             | Hot.                | Albuminoid. |        |            |            |           |                       |                  |
|         |                      |             |                 |        |                   |                     | Free.       | Total. | Dissolved. | Suspended. |           |                       |                  |
| 10851   | Beachwood Avenue.    | Distinct.   | Cons., fibrous. | 0.65   | Decided, musty.   | Distinct, musty.    | .0120       | .0336  | .0270      | .0066      | 37.18     | .0008                 | .7521            |
| 10852   | Opposite Islands.    | Distinct.   | Slight, earthy. | 0.50   | Decided, fishy.   | Decided, clam       | .0520       | .1104  | .0392      | .0712      | 412.1     | .0025                 | 1.3335           |
| 10853   | No. Beacon Street.   | Slight.     | Cons., rusty.   | 0.30   | Distinct, fishy.  | Faintly fishy       | .0784       | .0688  | .0286      | .0402      | 774.0     | .0034                 | 1.5800           |
| 10854   | Western Avenue.      | Slight.     | Slight, rusty.  | 0.18   | Distinct.         | V.faintly fishy.    | .0672       | .0544  | .0160      | .0384      | 1156.5    | .0030                 | 2.1804           |
| 10855   | Cambridge Cemetery.  | Slight.     | Slight, rusty.  | 0.20   | Distinct.         | Faintly clam.       | .0720       | .0408  | .0216      | .0192      | 1050.0    | .0028                 | 2.1804           |
| 10856   | No. Harvard Street.  | Slight.     | Slight.         | 0.12   | Faint.            | Faintly musty.      | .0776       | .0270  | .0196      | .0074      | 1472.5    | .0038                 | 2.4427           |
| 10857   | Cambridge Street.    | V. slight.  | Slight.         | 0.09   | Faint.            | Faintly musty.      | .0760       | .0460  | .0198      | .0262      | 1485.0    | .0027                 | 2.4866           |
| 10858   | Essex St., .         | V. slight.  | Slight.         | 0.10   | Faint.            | Decided, dis'g'ble. | .0840       | .0330  | .0200      | .0130      | 1476.0    | .0026                 | 2.9952           |
| 10859   | Harvard Bridge.      | V. slight.  | Slight.         | 0.08   | V. faint or none. | Faint.              | .0696       | .0296  | .0170      | .0126      | 1630.0    | .0027                 | 2.8392           |
| 10860   | W. Boston Bridge.    | V. slight.  | V. slight.      | 0.04   | None.             | V. faint or none.   | .0320       | .0154  | .0128      | .0026      | 1725.0    | .0015                 | 2.9016           |
| 10861   | Craigie's Bridge.    | V. slight.  | V. slight       | 0.04   | None.             | None.               | .0232       | .0135  | .0092      | .0046      | 1737.0    | .0012                 | 3.1574           |
| 10862   | Charles Riv. Bridge. | V. slight.  | V. slight.      | 0.01   | Faint, musty.     | Faint.              | .0224       | .0114  | .0096      | .0018      | 1747.0    | .0007                 | 3.6192           |

**CHARLES RIVER.**

*Chemical Examination of Water from the Tidal Portion of Charles River at Various Points, during Low Water of Neap Tides, Aug. 17, 1893.*

[Parts per 100,000.]

| Number. | LOCALITY.            | APPEARANCE. |                 |        | ODOR.               |                      | AMMONIA.    |        |            |            | Chlorine. | Nitrogen as Nitrides. | Oxygen Consumed. |
|---------|----------------------|-------------|-----------------|--------|---------------------|----------------------|-------------|--------|------------|------------|-----------|-----------------------|------------------|
|         |                      | Turbidity.  | Sediment.       | Color. | Cold.               | Hot.                 | Albuminoid. |        |            |            |           |                       |                  |
|         |                      |             |                 |        |                     |                      | Free.       | Total. | Dissolved. | Suspended. |           |                       |                  |
| 10822   | Beechwood Avenue.    | -           | -               | -      | -                   | -                    | -           | -      | -          | -          | -         | -                     | -                |
| 10823   | Opposite Islands.    | Decided.    | Cons.           | 0.90   | Decided, musty.     | Decided, musty.      | .0016       | .0640  | .0336      | .0304      | 10.80     | .0004                 | 1.6432           |
| 10824   | No. Beacon Street.   | Distinct.   | Cons., dark.    | 0.95   | Decided, musty.     | Distinct, musty.     | .0120       | .0848  | .0274      | .0574      | 22.12     | .0003                 | 1.4694           |
| 10825   | Western Avenue.      | Distinct.   | Slight, brown.  | 0.45   | Distinct, peculiar. | Decided, fishy.      | .0480       | .0834  | .0290      | .0544      | 434.3     | .0330                 | 1.3209           |
| 10826   | Cambridge Cemetery.  | Distinct.   | Cons., brown.   | 0.40   | Distinct, peculiar. | Decided, peculiar.   | .0576       | .0960  | .0296      | .0664      | 408.7     | .0028                 | 1.6116           |
| 10827   | No. Harvard Street.  | Distinct.   | Slight.         | 0.40   | Faint, peculiar.    | Distinct, peculiar.  | .0736       | .1424  | .0404      | .1020      | 634.5     | .0038                 | 1.6116           |
| 10828   | Cambridge Street.    | Distinct.   | Slight.         | 0.35   | Faint, peculiar.    | Distinct, peculiar.  | .0792       | .0798  | .0294      | .0504      | 788.5     | .0042                 | 1.8644           |
| 10829   | Essex St.,           | Slight.     | Slight.         | 0.20   | Faint, peculiar.    | Disagreeable, fishy. | .0774       | .0392  | .0240      | .0152      | 1198.5    | .0040                 | 2.5438           |
| 10830   | Harvard Bridge.      | Slight.     | Slight, earthy. | 0.15   | Faint.              | Faint.               | .0668       | .0286  | .0208      | .0078      | 1432.5    | .0035                 | 2.9704           |
| 10831   | W. Boston Bridge.    | Slight.     | Slight.         | 0.15   | V. faint or none.   | V. faint or none     | .0670       | .0230  | .0170      | .0060      | 1547.5    | .0034                 | 3.0494           |
| 10832   | Craigie's Bridge.    | Slight.     | Slight.         | 0.10   | None.               | V. faint or none.    | .0670       | .0202  | .0160      | .0042      | 1554.0    | .0034                 | 2.8440           |
| 10833   | Charles Riv. Bridge. | Slight.     | Slight.         | 0.05   | None.               | None.                | .0578       | .0166  | .0142      | .0024      | 1612.0    | .0044                 | 2.9704           |

**DEERFIELD RIVER.**

*Chemical Examination of Water from the Deerfield River above Shelburne Falls.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |                | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|----------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |                |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Sus-<br>pended |           |             |           |                  |           |
| 10951   | 1893.<br>Sept. 1    | Slight.     | Slight.    | 0.93   | 3.45                    | 1.70              | .0000    | .0138       | .0122      | .0016          | .04       | .0050       | .0000     | .8848            | 1.3       |
| 11179   | Oct. 12             | None.       | V. slight. | 0.50   | 3.20                    | 1.35              | .0000    | .0112       | .0090      | .0022          | .10       | .0000       | .0000     | .5913            | 1.6       |
| 11544   | Dec. 26             | Distinct.   | Heavy.     | 0.35   | 2.90                    | 1.50              | .0606    | .0180       | .0116      | .0064          | .06       | .0109       | .0001     | .5796            | 0.5       |
| Av.     | .....               | .....       | .....      | 0.59   | 3.18                    | 1.52              | .0002    | .0143       | .0109      | .0034          | .07       | .0050       | .0000     | .6852            | 1.1       |

Iron, .0092. Odor, faintly vegetable. — The samples were collected from the river about a mile above the bridge in the village of Shelburne Falls.

*Microscopical Examination.*

Average number of organisms, 83 per cubic centimeter.

## HOUSATONIC RIVER.

## HOUSATONIC RIVER.

Regular monthly examinations of the water of this river were made from March to the end of the year with a view to determining the extent to which the river is polluted by the sewage of the city of Pittsfield and other places upon its watershed. The samples were collected at New Lenox, which is distant about 3.9 miles by the river below the place where the sewage of Pittsfield is discharged into the stream. The drainage area of the river at New Lenox is 145.6 square miles, and the population on this area, by the census of 1890, was 23,300, equivalent to a population of 160 per square mile. Of the total population, 17,281 were in the city of Pittsfield.

*Chemical Examination of Water from the Housatonic River at New Lenox.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |        |             |       | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|----------------|--------|-------------------------|-------------------|----------|--------|-------------|-------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Total. | Albuminoid. |       |           | Nitrates.   | Nitrites. |                  |           |
|         | 1893.               |             |                |        |                         |                   |          |        |             |       |           |             |           |                  |           |
| 10167   | Mar. 27             | Distinct.   | Cons., clayey. | 0.25   | 5.65                    | 1.60              | .0044    | .0190  | .0142       | .0048 | .10       | .0200       | .0002     | .3504            | 3.5       |
| 10324   | Apr. 27             | Slight.     | Cons.          | 0.15   | 7.80                    | 2.05              | .0052    | .0114  | .0098       | .0016 | .20       | .0180       | .0001     | .3467            | 5.6       |
| 10462   | May 31              | Slight.     | Cons.          | 0.20   | 10.25                   | 2.25              | .0022    | .0122  | .0098       | .0024 | .16       | .0200       | .0002     | .3600            | 7.6       |
| 10578   | June 29             | Distinct.   | Slight.        | 0.20   | 10.55                   | 2.15              | .0080    | .0196  | .0142       | .0054 | .21       | .0200       | .0005     | .4305            | 7.7       |
| 10709   | July 26             | Distinct.   | Cons., milky.  | 0.20   | 12.40                   | 2.70              | .0078    | .0238  | .0172       | .0066 | .18       | .0120       | .0020     | .2960            | 8.1       |
| 10897   | Aug. 23             | Slight.     | Slight.        | 0.55   | 11.60                   | 3.10              | .0162    | .0202  | .0172       | .0030 | .19       | .0230       | .0067     | .7189            | 8.3       |
| 11068   | Sept. 20            | Slight.     | Slight.        | 0.40   | 11.10                   | 2.70              | .0060    | .0186  | .0166       | .0020 | .14       | .0120       | .0030     | .4346            | 8.6       |
| 11221   | Oct. 17             | Slight.     | Slight.        | 0.55   | 11.15                   | 2.55              | .0056    | .0206  | .0162       | .0044 | .17       | .0100       | .0004     | .5282            | 7.7       |
| 11384   | Nov. 23             | Distinct.   | Cons.          | 0.23   | 10.25                   | 1.45              | .0008    | .0126  | .0092       | .0034 | .19       | .0200       | .0004     | .4242            | 8.1       |
| 11555   | Dec. 26             | Decided.    | Heavy.         | 0.25   | 6.50                    | 1.55              | .0014    | .0162  | .0094       | .0068 | .10       | .0200       | .0001     | .3503            | 4.3       |
| Av.     | .....               |             |                | 0.30   | 9.73                    | 2.21              | .0058    | .0174  | .0134       | .0040 | .16       | .0175       | .0014     | .4180            | 7.0       |

Iron, .0140. Odor, generally decidedly mouldy or musty, rarely none. — The samples were collected from the river.

**HOUSATONIC RIVER.***Microscopical Examination of Water from the Housatonic River at New Lenox.*

[Number of organisms per cubic centimeter.]

|                                   | 1893. |      |       |       |       |      |       |      |      |      |
|-----------------------------------|-------|------|-------|-------|-------|------|-------|------|------|------|
|                                   | Mar.  | Apr. | June. | July. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
| Day of examination, . . . . .     | 28    | 29   | 1     | 1     | 28    | 29   | 22    | 20   | 25   | 28   |
| Number of sample, . . . . .       | -     | -    | -     | -     | -     | -    | -     | -    | -    | -    |
| <b>PLANTS.</b>                    |       |      |       |       |       |      |       |      |      |      |
| Diatomaceæ, . . . . .             | 0     | 7    | 137   | 1     | 36    | 2    | 3     | 9    | 31   | 75   |
| Asterionella, . . . . .           | 0     | 0    | 1     | 0     | 0     | 0    | 0     | 0    | 20   | 8    |
| Fragilaria, . . . . .             | 0     | 0    | 0     | 0     | 0     | 0    | 0     | 0    | 0    | 10   |
| Melosira, . . . . .               | 0     | 0    | 4     | 0     | 0     | 0    | 0     | 7    | 6    | 0    |
| Navicula, . . . . .               | 0     | pr.  | pr.   | 0     | 0     | 1    | 0     | 0    | 2    | 1    |
| Synedra, . . . . .                | 0     | 7    | 132   | 1     | 36    | 1    | 3     | 2    | 3    | 56   |
| Algæ, . . . . .                   | 0     | 0    | 12    | 2     | 7     | 0    | 0     | 0    | 0    | 0    |
| Protococcus, . . . . .            | 0     | 0    | 10    | 0     | 5     | 0    | 0     | 0    | 0    | 0    |
| Zoospores, . . . . .              | 0     | 0    | 2     | 2     | 2     | 0    | 0     | 0    | 0    | 0    |
| Fungi, . . . . .                  | 0     | pr.  | 24    | 340   | 40    | 160  | 32    | 106  | 7    | 73   |
| Crenothrix, . . . . .             | 0     | pr.  | 24    | 340   | 40    | 160  | 32    | 106  | 5    | 48   |
| Molds, . . . . .                  | 0     | 0    | 0     | 0     | 0     | 0    | 0     | pr.  | 2    | 25   |
| <b>ANIMALS.</b>                   |       |      |       |       |       |      |       |      |      |      |
| Rhizopoda, Difflugia, . . . . .   | 0     | 0    | 0     | 0     | 0     | 2    | 0     | 0    | 0    | 0    |
| Infusoria, . . . . .              | 2     | 1    | 15    | 3     | 8     | 0    | 0     | 0    | 1    | 5    |
| Ciliated Infusorian, . . . . .    | 0     | 0    | pr.   | 0     | 0     | 0    | 0     | 0    | 0    | 1    |
| Dinobryon, . . . . .              | 0     | 1    | 12    | 0     | 0     | 0    | 0     | 0    | 0    | 0    |
| Euglena, . . . . .                | 0     | 0    | 0     | 1     | 1     | 0    | 0     | 0    | 0    | 0    |
| Monas, . . . . .                  | 0     | pr.  | 3     | 2     | 1     | 0    | 0     | 0    | 0    | 3    |
| Paramœcium, . . . . .             | 2     | 0    | 0     | 0     | 0     | 0    | 0     | 0    | 0    | 0    |
| Peridinium, . . . . .             | 0     | 0    | 0     | 0     | 3     | 0    | 0     | 0    | 1    | 1    |
| Tintinnidium, . . . . .           | 0     | 0    | 0     | 0     | 3     | 0    | 0     | 0    | 0    | 0    |
| Miscellaneous, Zoöglæa, . . . . . | 80    | 78   | 112   | 48    | 80    | 4    | 0     | 14   | 108  | 124  |
| TOTAL, . . . . .                  | 82    | 80   | 300   | 394   | 171   | 168  | 35    | 129  | 147  | 277  |

**MERRIMACK RIVER.**

The usual monthly examinations of the water of this river opposite the intakes of the Lowell and the Lawrence Water Works have been continued during 1893, the detailed results of which may be found on pages 181 and 193 of this volume. A comparison of the analyses made at these two places during the year is given in the following table:—

## MERRIMACK RIVER.

*Table comparing the Analyses above Lowell with those above Lawrence, 1893.*

[Parts per 100,000.]

|                                                   | Color. | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Hardness. |
|---------------------------------------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|-----------|
|                                                   |        | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |           |
|                                                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |           |
| Number of determinations com-<br>pared, . . . . . | 12     | 12                              | 12                   | 12       | 12          | 12         | 12              | 12        | 12             | 12        | 12        |
| Mean of analyses above Lowell,                    | 0.33   | 3.39                            | 1.18                 | .0026    | .0149       | .0120      | .0029           | .167      | .0083          | .0001     | 1.1       |
| Mean of analyses above Law-<br>rence, . . . . .   | 0.42   | 3.86                            | 1.48                 | .0057    | .0181       | .0141      | .0040           | .202      | .0081          | .0002     | 1.1       |
| Increase, . . . . .                               | 0.09   | 0.47                            | 0.30                 | .0031    | .0032       | .0021      | .0011           | .035      | .0002*         | .0001     | 0.0       |

In order to compare these results with similar ones obtained in previous years, another table is presented, which contains the increase in impurities as the water passes from a point above Lowell to Lawrence, as given in the last line of the above table, and the corresponding increase in previous years:—

*Increase in the Amount of Impurities in the Merrimack River Water, from a Point above Lowell to Lawrence, as determined by the Regular Monthly Examinations of Different Years.*

[Parts per 100,000.]

| DATE.                  | Color. | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Hardness. |
|------------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|-----------|
|                        |        | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |           |
|                        |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |           |
| Increase, 1887-1889, . | 0.01   | 0.23                            | 0.09                 | .0007    | .0027       | .0017      | .0009           | .026      | .0003*         | .0000     | -         |
| Increase, 1890, . .    | 0.05   | 0.62                            | 0.22*                | .0016    | .0023       | .0017      | .0006           | .028      | .0020*         | .0000     | 0.2       |
| Increase, 1891, . .    | 0.02*  | 0.29                            | 0.07                 | .0021    | .0023       | .0021      | .0002           | .035      | .0030*         | .0000     | 0.1       |
| Increase, 1892, . .    | 0.06   | 0.48                            | 0.12                 | .0019    | .0037       | .0037      | .0000           | .039      | .0013*         | .0000     | 0.0       |
| Increase, 1893, . .    | 0.09   | 0.47                            | 0.30                 | .0031    | .0032       | .0021      | .0011           | .035      | .0002*         | .0001     | 0.0       |

The average flow of the river at Lawrence, per twenty-four hours, during the days on which samples were collected, was for the above periods, respectively, at the rate of 9,145, 9,948, 7,931, 5,433, and 8,126 cubic feet per second.

\* Decrease.



## NASHUA RIVER.

## NASHUA RIVER.

*Chemical Examination of Water from the North Branch of the Nashua River, below Fitchburg.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                                |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|--------------------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment.                      | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                     |                                |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1893.   |                     |                     |                                |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 9919    | Jan. 23             | Decided.            | Cons.,<br>gray.                | 0.40   | 12.90                           | 3.00                 | .1088    | .0498       | .0400      | .0098           | 1.19      | .0150          | .0012     | 1.1534           | 2.9       |
| 10049   | Feb. 27             | Decided.            | Cons.,<br>gray.                | 0.40   | 8.70                            | 1.30                 | .0390    | .0380       | .0210      | .0170           | 1.30      | .0200          | .0012     | .7632            | 2.6       |
| 10150   | Mar. 20             | Decided.            | Cons.,<br>gray.                | 0.38   | 3.90                            | 1.55                 | .0096    | .0242       | .0132      | .0110           | .32       | .0100          | .0001     | .3852            | 1.3       |
| 10313   | Apr. 25             | Distinct,<br>milky. | Cons.,<br>gray.                | 0.40   | 4.45                            | 1.55                 | .0116    | .0242       | .0176      | .0066           | .28       | .0100          | .0004     | .5037            | 1.1       |
| 10436   | May 22              | Distinct.           | Cons.,<br>floc'nt,<br>fibrous. | 0.60   | 4.15                            | 1.50                 | .0230    | .0246       | .0200      | .0046           | .28       | .0250          | .0003     | .5662            | 0.8       |
| 10534   | June 19             | Decided,<br>milky.  | Heavy,<br>brown.               | 0.60   | 7.25                            | 1.85                 | .0620    | .0336       | .0264      | .0072           | .73       | .0070          | .0013     | .5293            | 1.9       |
| 10883   | July 19             | Distinct.           | Cons.                          | 0.50   | 8.75                            | 2.10                 | .0630    | .0388       | .0326      | .0062           | .92       | .0030          | .0100     | .4884            | 2.5       |
| 10882   | Aug. 23             | Decided.            | Heavy,<br>brown.               | 1.00   | 10.90                           | 3.30                 | .0102    | .0120       | .0070      | .0030           | .87       | .0100          | .0030     | .8927            | 2.3       |
| 11050   | Sept. 19            | Decided.            | Cons.                          | 0.70   | 6.50                            | 2.35                 | .0422    | .0408       | .0256      | .0132           | .52       | .0090          | .0021     | .5822            | 1.8       |
| 11204   | Oct. 16             | Distinct.           | Cons.,<br>gray.                | 0.80   | 7.90                            | 2.40                 | .0980    | .0730       | .0540      | .0190           | .72       | .0200          | .0009     | .8109            | 2.5       |
| 11376   | Nov. 23             | Decided.            | Heavy,<br>gray.                | 0.60   | 8.60                            | 2.30                 | .0320    | .0450       | .0280      | .0170           | .61       | .0090          | .0009     | 1.0626           | 2.1       |
| 11509   | Dec. 18             | Decided.            | Cons.,<br>gray.                | 0.50   | 5.55                            | 2.70                 | .0240    | .0274       | .0228      | .0046           | .48       | .0030          | .0001     | .5751            | 1.6       |
| Av.     | .....               | .....               | .....                          | 0.57   | 7.46                            | 2.16                 | .0461    | .0360       | .0257      | .0103           | .69       | .0118          | .0018     | .6927            | 2.0       |

Iron, .0357. Odor, musty or offensive. — The samples were collected from the river about half a mile below the point where water from the tail-race of the Falulah Paper Company enters the stream.

*Microscopical Examination of Water from the North Branch of the Nashua River, below Fitchburg.*

[Number of organisms per cubic centimeter.]

|                     |   | 1893. |       |       |       |       |       |       |       |       |       |       |       |
|---------------------|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                     |   |       |       |       |       |       |       |       |       |       |       |       |       |
|                     |   | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, | . | 25    | 28    | 23    | 26    | 24    | 21    | 21    | 25    | 20    | 17    | 24    | 20    |
| Number of sample,   | . | 9919  | 10049 | 10150 | 10313 | 10436 | 10534 | 10683 | 10882 | 11050 | 11204 | 11376 | 11509 |
| PLANTS.             |   |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ,         | . | 0     | 0     | 0     | 9     | 35    | 11    | 3     | 60    | 13    | 6     | 20    | 1     |
| Asterionella,       | . | 0     | 0     | 0     | 1     | 4     | 0     | 0     | 0     | 0     | 0     | 0     | 1     |
| Cyclotella,         | . | 0     | 0     | 0     | pr.   | 0     | 1     | 1     | 20    | 0     | 0     | 0     | 0     |
| Gomphonema,         | . | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 10    | 0     | 0     | 0     | 0     |
| Melosira,           | . | 0     | 0     | 0     | 0     | 8     | 0     | 0     | 10    | 13    | 0     | 0     | 0     |
| Pinnularia,         | . | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 10    | 0     | 0     | 0     | 0     |
| Synedra,            | . | 0     | 0     | 0     | 7     | 20    | 8     | 2     | 10    | 0     | 0     | 2     | 0     |
| Tabellaria,         | . | 0     | 0     | 0     | 1     | 3     | 2     | 0     | 0     | 0     | 6     | 18    | 0     |

## NASHUA RIVER.

*Microscopical Examination of Water from the North Branch of the Nashua River, below Fitchburg — Concluded.*

[Number of organisms per cubic centimeter.]

|                           | 1893. |       |       |      |       |       |       |       |       |      |      |      |
|---------------------------|-------|-------|-------|------|-------|-------|-------|-------|-------|------|------|------|
|                           | Jan.  | Feb.  | Mar.  | Apr. | May.  | June. | July. | Aug.  | Sept. | Oct. | Nov. | Dec. |
| <b>PLANTS — Con.</b>      |       |       |       |      |       |       |       |       |       |      |      |      |
| Cyanophyceæ,              |       |       |       |      |       |       |       |       |       |      |      |      |
| Oscillaria, . . . .       | 0     | 0     | 0     | 0    | 1     | 2     | 0     | 25    | 1     | 0    | 0    | 0    |
| Algæ, Protococcus, .      | 0     | 0     | 0     | 0    | 0     | 0     | 0     | 0     | 52    | 0    | 0    | 0    |
| Fungi, . . . . .          | 0     | 38    | 0     | 8    | 168   | 13    | 2     | 45    | 160   | 54   | 14   | 7    |
| Beggiatoa, . . . .        | 0     | 0     | 0     | 1    | 0     | 0     | 0     | 0     | 0     | 6    | 10   | 0    |
| Crenothrix, . . . .       | 0     | 38    | 0     | 0    | 168   | 13    | 2     | 45    | 160   | 48   | 4    | 7    |
| Leptothrix, . . . .       | 0     | 0     | 0     | 7    | 0     | 0     | 0     | 0     | 0     | 0    | 0    | 0    |
| <b>ANIMALS.</b>           |       |       |       |      |       |       |       |       |       |      |      |      |
| Infusoria, . . . . .      | 0     | 0     | 0     | 1    | 15    | 0     | 0     | 10    | 14    | 25   | 4    | 3    |
| Dinobryon, . . . .        | 0     | 0     | 0     | 0    | 7     | 0     | 0     | 0     | 12    | 24   | 0    | 0    |
| Dinobryon cases, .        | 0     | 0     | 0     | 0    | 4     | 0     | 0     | 0     | 0     | 1    | 2    | 0    |
| Euglena, . . . . .        | 0     | 0     | 0     | 0    | 1     | 0     | 0     | 0     | 0     | 0    | 2    | 0    |
| Monas, . . . . .          | 0     | 0     | 0     | 1    | 3     | 0     | 0     | 5     | 0     | 0    | 0    | 2    |
| Peridinium, . . . .       | 0     | 0     | 0     | 0    | 0     | 0     | 0     | 0     | 2     | 0    | 0    | 1    |
| Trachelomonas, . .        | 0     | 0     | 0     | 0    | 0     | 0     | 0     | 5     | 0     | 0    | 0    | 0    |
| Miscellaneous, Zoöglea, . | 0     | 1,544 | 1,132 | 200  | 820   | 320   | 172   | 4,400 | 200   | 288  | 296  | 240  |
| TOTAL, . . . . .          | *     | 1,582 | 1,132 | 218  | 1,039 | 346   | 177   | 4,540 | 440   | 373  | 334  | 251  |

\* Amorphous matter very abundant.

*Chemical Examination of Water from the South Branch of the Nashua River at Clinton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1893.   |                     |             |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 10763   | Aug. 9              | V. slight.  | V. slight. | 0.15   | 3.40                            | 1.00                 | .0006    | .0130       | .0106      | .0024           | .26       | .0030          | .0001     | .3436            | 1.0       |
| 10994   | Sept. 8             | V. slight   | Slight.    | 0.30   | 3.95                            | 1.50                 | .0016    | .0178       | .0142      | .0036           | .26       | .0000          | .0002     | .3666            | 1.8       |
| 11163   | Oct. 10             | V. slight.  | Slight.    | 0.15   | 3.75                            | 1.20                 | .0004    | .0136       | .0098      | .0038           | .30       | .0000          | .0000     | .2233            | 1.7       |
| 11321   | Nov. 10             | V. slight.  | V. slight  | 0.80   | 4.90                            | 1.90                 | .0000    | .0164       | .0134      | .0030           | .36       | .0070          | .0003     | .7304            | 1.7       |
| 11452   | Dec. 5              | Slight.     | V. slight. | 0.65   | 3.95                            | 1.50                 | .0006    | .0184       | .0164      | .0020           | .23       | .0000          | .0000     | .6474            | 0.9       |
| Av.     | .....               | .....       | .....      | 0.41   | 3.99                            | 1.42                 | .0006    | .0158       | .0129      | .0029           | .28       | .0020          | .0001     | .4623            | 1.4       |

Iron, .0084. Odor, vegetable. — The samples were collected from the river above the dam of the Lancaster Manufacturing Company.

*Microscopical Examination.*

Average number of organisms, 97 per cubic centimeter.

**NASHUA RIVER.***Chemical Examination of Water from the Quinepozet River in Holden.*

[Parts per 100,000.]

| Number.     | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|-------------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|             |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|             |                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 10762       | 1893.<br>Aug. 9     | Slight.     | Slight.   | 0.60   | 3.40                            | 1.65                 | .0002    | .0188       | .0148      | .0040           | .28       | .0050          | .0001     | .5411            | 0.8       |
| 11015       | Sept. 12            | V. slight.  | Slight.   | 0.45   | 3.55                            | 1.50                 | .0004    | .0162       | .0132      | .0030           | .26       | .0070          | .0001     | .3978            | 1.3       |
| 11153       | Oct. 7              | Slight.     | Slight.   | 0.45   | 3.45                            | 1.20                 | .0000    | .0208       | .0156      | .0052           | .20       | .0030          | .0000     | .3927            | 0.6       |
| 11301       | Nov. 7              | V. slight.  | Slight.   | 1.10   | 4.35                            | 1.75                 | .0008    | .0206       | .0184      | .0022           | .32       | .0030          | .0002     | 1.0840           | 1.1       |
| 11446       | Dec. 5              | Distinct.   | Cons.     | 1.00   | 4.00                            | 1.75                 | .0004    | .0194       | .0178      | .0016           | .23       | .0040          | .0001     | .8229            | 0.8       |
| Av. . . . . | .....               | .....       | .....     | 0.72   | 3.75                            | 1.57                 | .0004    | .0192       | .0160      | .0032           | .26       | .0044          | .0001     | .6477            | 0.9       |

Iron, .0126. Odor, vegetable. — The samples were collected from the river at Smith's Woolen Mill in Holden, about one thousand feet from the line between Holden and West Boylston.

*Microscopical Examination.*

The average number of organisms, per cubic centimeter, found in these samples was 149; the greatest number present in any sample was 247, and the smallest number, 78.

*Chemical Examination of Water from the Stillwater River in Sterling.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |           |           | Chlorine. | NITROGEN AS |            | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|-----------|-----------|-----------|-------------|------------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |           | Nitrates. |           | Nitrites.   |            |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved |           |           |             | Suspended. |                  |           |
| 10766   | 1893.<br>Aug. 9     | V. slight.  | Slight.    | 0.40   | 3.60                    | 1.70              | .0006    | .0144       | .0122     | .0022     | .14       | .0000       | .0000      | .3713            | 0.6       |
| 11014   | Sept. 12            | V. slight.  | V. slight. | 0.60   | 3.40                    | 1.40              | .0004    | .0154       | .0132     | .0022     | .16       | .0050       | .0001      | .4524            | 0.9       |
| 11154   | Oct. 7              | V. slight.  | Slight.    | 0.20   | 2.95                    | 0.90              | .0008    | .0120       | .0106     | .0014     | .19       | .0030       | .0000      | .2579            | 0.6       |
| 11300   | Nov. 7              | None.       | Slight.    | 0.68   | 4.00                    | 1.45              | .0010    | .0182       | .0154     | .0028     | .26       | .0030       | .0001      | .7480            | 1.1       |
| 11447   | Dec. 5              | V. slight.  | V. slight. | 0.62   | 3.30                    | 1.45              | .0000    | .0136       | .0116     | .0020     | .16       | .0000       | .0001      | .6357            | 0.5       |
| Av..    | .....               | .....       | .....      | 0.50   | 3.45                    | 1.38              | .0006    | .0147       | .0126     | .0021     | .18       | .0022       | .0001      | .4931            | 0.7       |

Iron, .0088. Odor, of the first sample, none, becoming faintly vegetable on heating; of the remaining samples, distinctly vegetable, unchanged by heating. — The samples were collected from the river at a highway bridge about one mile above the line between Sterling and West Boylston.

*Microscopical Examination.*

Average number of organisms, 119 per cubic centimeter.

## QUINEBAUG RIVER.

## QUINEBAUG RIVER.

*Chemical Examination of Water from the Quinebaug River at Southbridge.*

[Parts per 100,000.]

| Number, | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. |           |
|---------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. | Oxygen Consumed. | Hardness. |
|         |                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 11030   | 1893.<br>Sept. 15   | None.       | Slight.   | 0.28   | 3.55                            | 1.25                 | .0000    | .0160       | .0138      | .0022           | .24       | .0030          | .0001     | .3822            | 1.1       |

Iron, .0230. Odor, none. — The sample was collected from the river just above the Litchfield Spindle Company's dam at Shuttleville, at a time when the water in the river was very low. The dam at which the sample was collected is located about one and one-half miles above the main village of Southbridge.

*Microscopical Examination.*

Diatomaceæ, *Asterionella*, 2; *Navicula*, 5; *Synedra*, 4; *Tabellaria*, 1. Algæ, *Protococcus*, 12. Fungi, *Crenothrix*, 112. Miscellaneous, *Zoëglæa*, 11. Total, 147.

## SHAWSHEEN RIVER.

*Chemical Examination of Water from the Shawsheen River at Bedford.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 11309   | 1893.<br>Nov. 8     | V. slight.  | Cons.     | 1.40   | 7.50                            | 3.10                 | .0000    | .0340       | .0302      | .0038           | .58       | .0000          | .0000     | 1.4080           | 2.3       |
| 11310   | Nov. 8              | Slight.     | Cons.     | 1.20   | 7.85                            | 3.95                 | .0000    | .0282       | .0242      | .0040           | .60       | .0070          | .0003     | 1.5480           | 2.2       |

Iron in the first sample, .0130; in the second, .0110. Odor, distinctly vegetable and sweetish. — The first sample was collected from the river above the point where it is joined by Vine Brook; the last sample from the river about a quarter of a mile below the mouth of Vine Brook. These samples were collected in the vicinity of the upper end of a proposed storage reservoir surveyed by the city of Boston in 1886.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in the first sample was 155, consisting chiefly of *Crenothrix* and *Zoëglæa*; in the last sample 839 organisms were found, nearly all of which were *Crenothrix*.

## SHAWSHEEN RIVER.

*Chemical Examination of Water from the Shawsheen River at Wilmington.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 11312   | 1893.<br>Nov. 8     | V. slight.  | Cons.     | 1.00   | 6.50                            | 2.70                 | .0000    | .0248       | .0234      | .0014           | .54       | .0030          | .0001     | 1.0520           | 2.3       |

Iron, .0090. Odor, faintly vegetable, becoming stronger on heating. — The sample was collected from the river at the point where it was crossed by the old Middlesex Canal, between Wilmington and Billerica, at the location of the dam of a proposed storage reservoir.

*Microscopical Examination.*

Total number of organisms, 17 per cubic centimeter.

*Chemical Examination of Water from the Shawsheen River at North Andover.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            |           | Chlorine. | NITROGEN AS |       | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-----------|-------------|-------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            | Nitrates. |           | Nitrites.   |       |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |           |             |       |                  |           |
| 10559   | 1893.<br>June 22    | Slight.     | Cons.     | 0.85   | 5.35                    | 2.35              | .0106    | .0306       | .0254      | .0052      | .36       | .0250     | .0005       | .6162 | 1.3              |           |

Iron, .0135. Odor, distinctly vegetable and grassy. — The sample was collected from the river a short distance above its mouth.

*Microscopical Examination.*

Diatomaceæ, *Tubellaria*, 1. Fungi, *Crenothrix*, 400. Infusoria, *Monas*, 2. Miscellaneous, *Zoëglæa*, 188. Total, 591.

## STONY BROOK.

## STONY BROOK.

*Chemical Examination of Water from Stony Brook at Inlet to the New Conduit at Roxbury.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |           |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|-----------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.        | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |           |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                   |                   |        |                                 |                      |          | Total.      | Dissolved | Sus-<br>pended. |           |                |           |                  |           |
| 1893.   |                     |                   |                   |        |                                 |                      |          |             |           |                 |           |                |           |                  |           |
| 10621   | July 10             | Slight,<br>milky. | Slight,<br>dark.  | 0.30   | 16.25                           | 4.60                 | .0384    | .0302       | .0242     | .0060           | 1.99      | .2200          | .0120     | .2623            | 7.1       |
| 10962   | Sept. 5             | Slight.           | Slight,<br>brown. | 0.20   | 15.50                           | 4.30                 | .0408    | .0182       | .0160     | .0022           | 1.96      | .2300          | .0040     | .2760            | 6.1       |

Iron, .0137. Odor of the first sample, decidedly vegetable and mouldy; of the last, faintly vegetable. — The samples were collected from the brook at the gate-house at the entrance to the new conduit at Roxbury.

*Microscopical Examination.*

No. 10621. Diatomaceæ, *Cyclotella*, 16; *Diatoma*, 24; *Navicula*, 4; *Stauronella*, 2; *Synedra*, 1. Algae, *Cladonema*, 1; *Pediastrum*, 1; *Protococcus*, 2; *Scenedesmus*, 22; *Sorastrum*, 10; *Zoospores*, 1. Fungi, *Crenothrix*, 82. Miscellaneous, *Zooglyca*, 40. Total, 206.

No. 10962. Algae, *Scenedesmus*, 1; Fungi, *Crenothrix*, 6; *Molds*, 8. Infusoria, *Peridinium*, 1. Miscellaneous, *Zooglyca*, 24. Total, 40.

## TAUNTON RIVER.

Regular monthly examinations of the Taunton River above Taunton have been made as in previous years, and the results are printed in connection with analyses of water of the Taunton water supply on page 296. In the following table analyses are given of the water of Mill River, a tributary of the Taunton, near its mouth. The sewage of a portion of the city of Taunton is discharged into this river.

*Chemical Examination of Water from the Mill River at Taunton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                          | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |     |
|---------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|--------------------------|----------------|-----------|------------------|-----------|-----|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                          | Chlorine.      | Nitrates. | Nitrites.        |           |     |
|         |                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sul-<br>phur-<br>tended. |                |           |                  |           |     |
|         |                     |             |           |        |                                 |                      |          |             |            |                          |                |           |                  |           |     |
| 10693   | 1893.<br>July 25    | Distinct.   | Cons.     | 0.80   | 6.20                            | 2.05                 | .0794    | .0462       | .0290      | .0172                    | .84            | .0090     | .0008            | .6809     | 1.5 |
| 10913   | Aug. 29             | Slight.     | Cons.     | 2.00   | 6.80                            | 3.80                 | .0056    | .0326       | .0238      | .0088                    | .60            | .0050     | .0002            | 1.5958    | 1.0 |
| 11088   | Sept. 25            | Distinct.   | Cons.     | 0.99   | 6.70                            | 2.45                 | .1120    | .0324       | .0258      | .0066                    | 1.03           | .0120     | .0013            | .5936     | 2.2 |
| Av.     | .....               | .....       | .....     | 1.23   | 6.57                            | 2.77                 | .0657    | .0371       | .0262      | .0109                    | .82            | .0097     | .0008            | .9584     | 1.6 |

Iron, .0625. Odor of the first sample, decidedly musty; of the second, decidedly vegetable, becoming unpleasant on heating; of the last sample, decidedly musty and disagreeable, becoming offensive on heating. — The samples were collected from the river at the Ingell Street bridge near its mouth.

## TAUNTON RIVER.

*Microscopical Examination of Water from the Mill River at Taunton.*

[Number of organisms per cubic centimeter.]

|                                    | 1893.        |            |              |
|------------------------------------|--------------|------------|--------------|
|                                    | July.        | Aug.       | Sept.        |
| Day of examination, . . . . .      | 26           | 31         | 27           |
| Number of sample, . . . . .        | 10693        | 10913      | 11089        |
| <b>PLANTS.</b>                     |              |            |              |
| Diatomaceæ, . . . . .              | 2            | 8          | 0            |
| Fragilaria, . . . . .              | 0            | 5          | 0            |
| Synedra, . . . . .                 | 2            | 0          | 0            |
| Tabellaria, . . . . .              | 0            | 3          | 0            |
| Cyanophyceæ, Oscillaria, . . . . . | 1            | 0          | 1            |
| Algæ, Protococcus, . . . . .       | 78           | 0          | 0            |
| Fungi, Crenothrix, . . . . .       | 10           | 184        | 320          |
| <b>ANIMALS.</b>                    |              |            |              |
| Rhizopoda, Arcella, . . . . .      | 1            | 0          | 1            |
| Infusoria, . . . . .               | 4            | 5          | 2            |
| Encysted Protozoa, . . . . .       | 2            | 0          | 0            |
| Euglena, . . . . .                 | 0            | 0          | 1            |
| Monas, . . . . .                   | 2            | 3          | 0            |
| Peridinium, . . . . .              | 0            | 1          | 1            |
| Vorticella, . . . . .              | 0            | 1          | 0            |
| Vermes, Rotifer, . . . . .         | 0            | 0          | 1            |
| Miscellaneous, Zoöglæa, . . . . .  | 920          | 108        | 1,000        |
| <b>TOTAL, . . . . .</b>            | <b>1,014</b> | <b>285</b> | <b>1,325</b> |

## WARE RIVER.

*Chemical Examination of Water from Ware River at Cold Brook Station, Barre.*

[Parts per 100,000]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1893.   |                     |             |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 10919   | Aug. 30             | V. slight.  | V. slight. | 0.70   | 3.25                            | 1.85                 | .0000    | .0228       | .0188      | .0040           | .14       | .0000          | .0000     | .6794            | 0.5       |
| 11319   | Nov. 9              | V. slight.  | Slight.    | 1.00   | 4.50                            | 2.15                 | .0006    | .0232       | .0178      | .0054           | .26       | .0000          | .0000     | 1.0160           | 1.1       |
| 11353   | Nov. 23             | V. slight.  | V. slight. | 0.70   | 3.65                            | 1.45                 | .0004    | .0134       | .0116      | .0018           | .18       | .0000          | .0000     | .8778            | 0.9       |
| 11433   | Dec. 4              | V. slight.  | Slight.    | 0.65   | 3.70                            | 1.35                 | .0000    | .0152       | .0126      | .0026           | .17       | .0000          | .0000     | .6513            | 0.9       |
| Av.     | .....               | .....       | .....      | 0.76   | 3.78                            | 1.70                 | .0003    | .0157       | .0152      | .0035           | .19       | .0000          | .0000     | .8061            | 0.9       |

Iron, .0160. Odor, vegetable. — The samples were collected from the river at the railroad bridge near Cold Brook station, in the southeasterly part of the town of Barre.

*Microscopical Examination.*

Average number of organisms, 58 per cubic centimeter.

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**SUMMARY**

**OF**

**WATER SUPPLY STATISTICS;**

**ALSO**

**RECORDS OF RAINFALL AND FLOW OF STREAMS.**

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## SUMMARY OF WATER SUPPLY STATISTICS.

At the end of 1893 the State contained 30 cities and 322 towns. The towns of Medford and Everett became cities on Jan. 2, 1893, thus causing the change in the number of cities and towns since the previous year.

A public water supply was introduced during this year for the first time into the towns of Chester, North Brookfield and Provincetown, increasing the number of places supplied to 146. In addition to the new supplies for the places named above, new sources have been substituted for old ones in Attleborough, Chicopee, Easthampton, Orange and Taunton. In many other places additional works of less importance have been constructed to increase the capacity of the sources of supply.

It has been found by experience that there is unusual danger when water is taken directly from a running stream into which sewage is discharged, and it is therefore worthy of note that of the works constructed during the year those at Taunton, Chicopee and Orange were built for the purpose of abandoning the use of polluted streams as sources of supply, while at Lawrence, although the Merrimack River is still used as a source, the whole of the water used is filtered through a filter having an area of two and one-half acres to remove the disease germs which may be in the river water.

At Lowell new works for taking water from the ground have been constructed, which furnish a portion of the supply of the city, but the greater portion still comes from the Merrimack River.

The following table gives a classification, by population, of cities and towns having and not having public water supplies Dec. 31, 1893. The populations are taken from the census of 1890:—

| POPULATION<br>(1890).    | Number of<br>Places of Given<br>Population<br>having a Pub-<br>lic Water<br>Supply. | Total<br>Population of<br>Places<br>in Preceding<br>Column. | Number of<br>Places of Given<br>Population<br>not having a<br>Public<br>Water Supply. | Total<br>Population of<br>Places<br>in Preceding<br>Column. |
|--------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------|---------------------------------------------------------------------------------------|-------------------------------------------------------------|
| Under 500, . . . . .     | 0                                                                                   | 0                                                           | 28                                                                                    | 9,772                                                       |
| 500-1,000, . . . . .     | 5                                                                                   | 4,566                                                       | 63                                                                                    | 48,167                                                      |
| 1,000-1,500, . . . . .   | 6                                                                                   | 7,249                                                       | 43                                                                                    | 52,810                                                      |
| 1,500-2,000, . . . . .   | 8                                                                                   | 13,857                                                      | 27                                                                                    | 48,382                                                      |
| 2,000-2,500, . . . . .   | 9                                                                                   | 19,987                                                      | 14                                                                                    | 80,299                                                      |
| 2,500-3,000, . . . . .   | 7                                                                                   | 19,663                                                      | 18                                                                                    | 49,262                                                      |
| 3,000-3,500, . . . . .   | 8                                                                                   | 26,010                                                      | 5                                                                                     | 15,599                                                      |
| 3,500-4,000, . . . . .   | 7                                                                                   | 26,328                                                      | 2                                                                                     | 7,392                                                       |
| 4,000-4,500, . . . . .   | 11                                                                                  | 47,201                                                      | 5                                                                                     | 21,367                                                      |
| Above 4,500, . . . . .   | 85                                                                                  | 1,779,952                                                   | 1                                                                                     | 6,138                                                       |
| <b>TOTALS, . . . . .</b> | <b>146</b>                                                                          | <b>1,949,455</b>                                            | <b>206</b>                                                                            | <b>289,488</b>                                              |

From the totals given in the table it will be seen that, although but forty-one per cent. of the cities and towns in the State have a public water supply, yet the total population of places supplied represents 87.1 per cent. of the whole population of the State. In this estimate of the total population of municipalities supplied all of the inhabitants in them are included, and it consequently includes rather more than the actual number of persons to whom a public water supply is available; the difference, however, is not large. There are now but 6 towns having, by the census of 1890, a population exceeding 4,000, which are not provided with a public water supply. These are given in the following table:—

| TOWNS.                | Population in<br>1890. | TOWNS.                | Population in<br>1890. |
|-----------------------|------------------------|-----------------------|------------------------|
| Blackstone, . . . . . | 6,138                  | Winchendon, . . . . . | 4,390                  |
| Ipswich,* . . . . .   | 4,439                  | Rockport,* . . . . .  | 4,087                  |
| Millbury, . . . . .   | 4,428                  | Barnstable, . . . . . | 4,023                  |

\* Works for the supply of Ipswich and Rockport were begun in 1894.

In the following table the various water supplies are classified according to the dates when a fairly complete system of supply was first introduced into a city or town:—

| YEARS.                          | Number of<br>Places<br>Supplied. | YEARS.           | Number of<br>Places<br>Supplied. |
|---------------------------------|----------------------------------|------------------|----------------------------------|
| Previous to 1850, . . . . .     | 6                                | 1891, . . . . .  | 5                                |
| 1850-1859, inclusive, . . . . . | 4                                | 1892, . . . . .  | 1                                |
| 1860-1869, inclusive, . . . . . | 10                               | 1893, . . . . .  | 3                                |
| 1870-1879, inclusive, . . . . . | 44                               |                  |                                  |
| 1880-1889, inclusive, . . . . . | 68                               | TOTAL, . . . . . | 146                              |
| 1890, . . . . .                 | 5                                |                  |                                  |

Of the 30 cities in the Commonwealth, 28, having a total population in 1890 of 1,355,849, own their water works; while 2, having a total population of 38,598, are wholly supplied by private companies. Of the 116 towns having public water supplies, 69,\* with a total population of 360,260, are supplied from their own works, while 47, with a total population of 194,748, are supplied by private companies. The total population in both cities and towns owning their works is 1,716,109, against 233,346 in those supplied by private companies.

The following table gives statistics with regard to the consumption of water in many of the cities and towns in this State. The populations for 1893, as given in the table, were obtained in a somewhat

\* The figures in this paragraph differ somewhat from corresponding figures on page 5, owing to information received after the first figures were printed that the control of water works in two towns had passed from private companies to the public authorities.

arbitrary manner by adding three-fifths of the increase in population from 1885 to 1890 to the population as determined by the census taken in the latter year. The daily consumption per *inhabitant*, obtained by dividing the average daily consumption by the total population of the city or town in 1893, is less than the amount per *consumer*, because there are some in all cities and towns who do not use the public water supply. This difference between the number of inhabitants and consumers accounts, to a large extent, for the low rate, per inhabitant, in some towns where works have been in operation only a short time, and in consequence water has not been generally introduced; also, in towns where there are villages to which the public water supply has not been extended; but, after making all due allowance for the varying proportion of water takers, there is still a very great difference in the amount of water used per person in different places, which it is very difficult to account for.

*Statistics relating to the Consumption of Water in Various Cities and Towns.*

| CITY OR TOWN.                                                  | Population.<br>1893. | Average<br>Daily<br>Consumption.<br>Gallons.<br>1893. | Daily<br>Consumption<br>per<br>Inhabitant.<br>Gallons. | CITY OR TOWN.                | Population.<br>1893. | Average<br>Daily<br>Consumption.<br>Gallons.<br>1893. | Daily<br>Consumption<br>per<br>Inhabitant.<br>Gallons. |
|----------------------------------------------------------------|----------------------|-------------------------------------------------------|--------------------------------------------------------|------------------------------|----------------------|-------------------------------------------------------|--------------------------------------------------------|
| Abington and Rockland, . . .                                   | 10,067               | 312,000                                               | 31                                                     | Manchester, . . .            | 1,879                | 101,000                                               | 54                                                     |
| Andover, . . .                                                 | 8,400                | 285,000                                               | 45                                                     | Mansfield, . . .             | 3,729                | 209,000                                               | 56                                                     |
| Attleborough,* . .                                             | 8,036                | 218,000                                               | 27                                                     | Marblehead, . . .            | 8,613                | 191,000                                               | 22                                                     |
| Avon, . . .                                                    | 1,619                | 55,000                                                | 34                                                     | Marlborough, . .             | 15,524               | 440,000                                               | 28                                                     |
| Ayer, . . .                                                    | 2,124                | 71,000                                                | 33                                                     | Medford, . . .               | 12,300               | 611,000                                               | 50                                                     |
| Beverly, . . .                                                 | 11,802               | 843,000                                               | 71                                                     | Melrose, . . .               | 9,971                | 652,000                                               | 65                                                     |
| Boston (Cochituate Works), . . .                               | 444,575              | 47,453,000                                            | 107                                                    | Middleborough, .             | 8,605                | 197,000                                               | 30                                                     |
| Boston, Somerville, Chelsea, and Everett (Mystic Works), . . . | 128,458              | 11,162,000                                            | 87                                                     | Milton, . . .                | 4,713                | 129,000                                               | 27                                                     |
| Braintree, . . .                                               | 5,334                | 289,000                                               | 54                                                     | Montague, . . .              | 8,695                | 323,000                                               | 48                                                     |
| Bridgewater and East Bridge-water, . .                         | 7,472                | 145,000                                               | 19                                                     | Nantucket, . . .             | 3,343                | 86,000                                                | 26                                                     |
| Brockton, . . .                                                | 31,200               | 693,000                                               | 22                                                     | Natick, . . .                | 9,514                | 354,000                                               | 37                                                     |
| Brookline, . . .                                               | 13,847               | 1,216,000                                             | 88                                                     | Needham, . . .               | 3,305                | 106,000                                               | 32                                                     |
| Cambridge, . . .                                               | 76,250               | 6,123,000                                             | 80                                                     | New Bedford,† .              | 55,000               | 4,098,000                                             | 91                                                     |
| Canton, . . .                                                  | 4,634                | 186,000                                               | 40                                                     | Newburyport, . .             | 14,805               | 564,000                                               | 40                                                     |
| Cohasset, . . .                                                | 2,586                | 56,000                                                | 22                                                     | Newton, . . .                | 27,751               | 1,368,000                                             | 50                                                     |
| Cottage City, . .                                              | 1,392                | 58,000                                                | 45                                                     | No. Attleborough,            | 6,946                | 165,000                                               | 24                                                     |
| Danvers and Middleton, . . .                                   | 8,630                | 571,000                                               | 66                                                     | Norwood, . . .               | 4,219                | 208,000                                               | 49                                                     |
| Dedham, . . .                                                  | 7,412                | 303,000                                               | 41                                                     | Quincy, . . .                | 19,470               | 729,000                                               | 37                                                     |
| Easton, . . .                                                  | 4,820                | 92,000                                                | 19                                                     | Randolph and Holbrook, . . . | 6,588                | 290,000                                               | 44                                                     |
| Fall River, . . .                                              | 84,916               | 2,334,000                                             | 27                                                     | Reading, . . .               | 4,418                | 222,000                                               | 50                                                     |
| Foxborough, . . .                                              | 3,005                | 81,000                                                | 27                                                     | Revere and Winthrop, . . .   | 10,425               | 723,000                                               | 69                                                     |
| Frammingham, . .                                               | 9,818                | 282,000                                               | 29                                                     | Salem, . . .                 | 32,427               | 2,138,000                                             | 66                                                     |
| Franklin, . . .                                                | 5,341                | 126,000                                               | 24                                                     | Sharon, . . .                | 1,817                | 84,000                                                | 19                                                     |
| Gardner, . . .                                                 | 9,108                | 641,000                                               | 70                                                     | Swampscott and Nahant, . . . | 4,600                | 291,000                                               | 62                                                     |
| Gloucester, . . .                                              | 26,421               | 774,000                                               | 29                                                     | Taunton, . . .               | 26,513               | 1,061,000                                             | 40                                                     |
| Hyde Park, . . .                                               | 11,281               | 499,000                                               | 44                                                     | Wakefield and Stoneham, . .  | 13,987               | 553,000                                               | 40                                                     |
| Lawrence, . . .                                                | 48,128               | 3,153,000                                             | 66                                                     | Waltham, . . .               | 21,166               | 1,055,000                                             | 50                                                     |
| Lowell, . . .                                                  | 85,850               | 6,817,000                                             | 79                                                     | Ware, . . .                  | 8,124                | 209,000                                               | 26                                                     |
| Lynn and Saugus,†                                              | 69,653               | 3,744,000                                             | 54                                                     | Watertown and Belmont, . . . | 9,948                | 477,000                                               | 48                                                     |
| Malden, . . .                                                  | 27,006               | 1,451,000                                             | 54                                                     | Wellesley, . . .             | 3,951                | 201,000                                               | 51                                                     |
|                                                                |                      |                                                       |                                                        | Whitman, . . .               | 4,948                | 189,000                                               | 38                                                     |
|                                                                |                      |                                                       |                                                        | Woburn, . . .                | 14,549               | 926,000                                               | 64                                                     |

\* May to December only.

† The growth of these places has been very rapid since 1890, and the estimates of population given by the superintendents of water works have therefore been used.

## RAINFALL.

The rainfall for the year 1893 was 0.56 inches in excess of the normal, but was very unevenly distributed. The greatest excess of rainfall occurred in February, May and December, while there was a deficiency in all the summer and autumn months with the exception of August, in which there was a slight excess. The effect of the distribution was to cause a very high flow in the streams in the spring months and a very low flow in the summer and autumn.

The average annual rainfall \* in Massachusetts, as deduced from long-continued observations in various parts of the State, is 45.14 inches. In the following table is given the normal rainfall for each month in the year, the rainfall for each month in 1893 and the departures from the normal. †

|                 | Normal<br>Rainfall.<br>Inches. | Rainfall,<br>1893.<br>Inches. | Excess or<br>Deficiency.<br>Inches. |                  | Normal<br>Rainfall.<br>Inches. | Rainfall,<br>1893.<br>Inches. | Excess or<br>Deficiency.<br>Inches. |
|-----------------|--------------------------------|-------------------------------|-------------------------------------|------------------|--------------------------------|-------------------------------|-------------------------------------|
| <b>1893.</b>    |                                |                               |                                     | <b>1893.</b>     |                                |                               |                                     |
| January, . . .  | 3.99                           | 2.83                          | -1.16                               | August, . . .    | 4.42                           | 4.85                          | +0.43                               |
| February, . . . | 3.74                           | 6.84                          | +3.10                               | September, . . . | 3.31                           | 2.16                          | -1.15                               |
| March, . . .    | 4.05                           | 3.80                          | -0.25                               | October, . . .   | 3.87                           | 3.81                          | -0.06                               |
| April, . . .    | 3.32                           | 3.83                          | +0.51                               | November, . . .  | 3.96                           | 2.10                          | -1.86                               |
| May, . . .      | 3.73                           | 5.38                          | +1.65                               | December, . . .  | 3.57                           | 4.99                          | +1.42                               |
| June, . . .     | 3.30                           | 2.90                          | -0.40                               |                  |                                |                               |                                     |
| July, . . .     | 3.88                           | 2.21                          | -1.67                               | Totals, . . .    | 45.14                          | 45.70                         | +0.56                               |

To enable the condition preceding the collection of samples of water in any part of the State to be understood, the following tables are presented, which give the daily rainfall in inches at nine stations scattered about the State : —

\* Including melted snow.

† This and subsequent tables of rainfall have been prepared from the records of the New England Weather Service.

*Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected.*

January, 1893.

February, 1893.

| DAY<br>OF<br>MONTH. | Ludlow. | Gilbertville. | Fitchburg. | Frammingham. | Chestnut Hill,<br>Boston. | Lawrence. | Salem. | Taunton. | New Bedford. | DAY<br>OF<br>MONTH. | Ludlow. | Gilbertville. | Fitchburg. | Frammingham. | Chestnut Hill,<br>Boston. | Lawrence. | Salem. | Taunton.† | New Bedford. |
|---------------------|---------|---------------|------------|--------------|---------------------------|-----------|--------|----------|--------------|---------------------|---------|---------------|------------|--------------|---------------------------|-----------|--------|-----------|--------------|
| 1, . .              | 0.50    | 0.38          | 0.46       | *            | 1.04                      | *         | *      | 0.23     | *            | 1, . .              | 0.15    | *             | -          | 0.28         | -                         | *         | *      | *         | *            |
| 2, . .              | 1.05    | 0.72          | 0.50       | 0.88         | -                         | 0.76      | 0.76   | 0.75     | 1.12         | 2, . .              | 0.10    | 0.24          | 0.11       | -            | -                         | 0.15      | 0.26   | 0.42      | 0.40         |
| 3, . .              | -       | -             | -          | -            | -                         | -         | -      | -        | -            | 3, . .              | 0.20    | 0.25          | 0.25       | 0.30         | 0.50                      | 0.32      | 0.28   | 0.17      | 0.10         |
| 4, . .              | -       | -             | -          | -            | -                         | -         | -      | -        | -            | 4, . .              | -       | -             | -          | -            | -                         | -         | -      | -         | -            |
| 5, . .              | 0.05    | -             | 0.18       | *            | -                         | *         | *      | -        | *            | 5, . .              | -       | -             | -          | -            | -                         | -         | -      | -         | -            |
| 6, . .              | 0.15    | 0.16          | 0.14       | 0.95         | 0.63                      | 0.31      | 0.50   | 0.55     | 0.40         | 6, . .              | 0.40    | *             | 0.69       | *            | *                         | *         | *      | 0.25      | *            |
| 7, . .              | -       | -             | -          | -            | -                         | -         | -      | -        | -            | 7, . .              | 0.50    | 1.17          | 0.32       | 0.56         | 0.54                      | 0.56      | 0.36   | 0.63      | 1.04         |
| 8, . .              | -       | -             | -          | -            | -                         | -         | -      | -        | -            | 8, . .              | -       | -             | -          | -            | -                         | -         | -      | -         | -            |
| 9, . .              | 0.30    | *             | 0.19       | *            | 0.54                      | *         | *      | 0.35     | 0.50         | 9, . .              | *       | -             | -          | *            | *                         | *         | -      | *         | *            |
| 10, . .             | 0.35    | 0.41          | 0.17       | 0.50         | -                         | 0.42      | 0.21   | -        | -            | 10, . .             | 1.10    | 2.00          | 1.38       | 1.16         | 1.08                      | 0.79      | -      | 1.38      | 1.20         |
| 11, . .             | -       | -             | -          | *            | -                         | -         | -      | -        | -            | 11, . .             | -       | -             | -          | -            | -                         | -         | -      | -         | -            |
| 12, . .             | -       | -             | 0.02       | 0.03         | -                         | -         | 0.01   | 0.03     | -            | 12, . .             | -       | -             | -          | -            | -                         | -         | -      | -         | -            |
| 13, . .             | -       | -             | -          | 0.02         | -                         | -         | -      | 0.07     | 0.80         | 13, . .             | 0.80    | 0.81          | 0.60       | 1.50         | 1.44                      | *         | *      | *         | *            |
| 14, . .             | -       | -             | -          | *            | -                         | -         | -      | -        | -            | 14, . .             | 0.40    | 0.52          | 0.83       | -            | -                         | 0.94      | 1.47   | 1.48      | 1.35         |
| 15, . .             | -       | 0.08          | 0.03       | 0.12         | 0.10                      | 0.05      | 0.08   | 0.40     | 0.16         | 15, . .             | 0.10    | -             | -          | -            | -                         | -         | -      | -         | -            |
| 16, . .             | -       | -             | -          | -            | -                         | -         | 0.05   | -        | 0.03         | 16, . .             | -       | -             | 0.01       | -            | -                         | -         | -      | -         | -            |
| 17, . .             | -       | -             | -          | -            | -                         | -         | -      | -        | -            | 17, . .             | *       | *             | -          | *            | *                         | *         | *      | *         | *            |
| 18, . .             | -       | -             | -          | -            | -                         | -         | -      | -        | *            | 18, . .             | 1.00    | 0.80          | 0.71       | 1.18         | 1.55                      | 0.64      | 0.80   | 1.60      | 1.35         |
| 19, . .             | 0.05    | 0.03          | -          | -            | -                         | -         | -      | -        | -            | 19, . .             | *       | *             | -          | *            | -                         | *         | 0.05   | *         | *            |
| 20, . .             | -       | -             | -          | -            | -                         | -         | -      | -        | -            | 20, . .             | 0.30    | 0.33          | 0.20       | 0.08         | -                         | 0.27      | 0.12   | 0.10      | 0.24         |
| 21, . .             | -       | -             | -          | -            | -                         | -         | -      | -        | -            | 21, . .             | -       | -             | -          | *            | -                         | -         | -      | -         | 0.68         |
| 22, . .             | -       | -             | -          | -            | -                         | -         | -      | -        | -            | 22, . .             | 0.40    | 0.90          | 1.10       | 1.88         | 2.25                      | 0.67      | 1.41   | 0.75      | 0.37         |
| 23, . .             | 0.05    | -             | -          | 0.03         | -                         | 0.03      | 0.05   | 0.08     | 0.05         | 23, . .             | -       | -             | -          | -            | -                         | *         | -      | -         | -            |
| 24, . .             | -       | -             | -          | 0.03         | -                         | -         | -      | -        | -            | 24, . .             | 0.20    | -             | 0.32       | 0.22         | 0.23                      | 0.33      | 0.32   | *         | 0.60         |
| 25, . .             | 0.30    | 0.18          | 0.15       | 0.07         | -                         | 0.10      | 0.07   | -        | -            | 25, . .             | 0.20    | 0.22          | 0.14       | 0.31         | 0.28                      | *         | *      | 0.66      | 0.33         |
| 26, . .             | -       | -             | -          | -            | -                         | -         | -      | -        | -            | 26, . .             | 0.10    | -             | -          | -            | -                         | 0.17      | 0.32   | -         | -            |
| 27, . .             | -       | -             | -          | -            | -                         | -         | -      | -        | -            | 27, . .             | -       | -             | -          | -            | -                         | -         | -      | -         | -            |
| 28, . .             | -       | -             | -          | -            | -                         | *         | -      | 0.40     | -            | 28, . .             | 0.40    | 0.26          | 0.25       | 0.68         | 0.44                      | 0.40      | 0.40   | 0.10      | 0.40         |
| 29, . .             | 0.40    | 0.40          | -          | 0.28         | 0.43                      | 0.28      | 0.35   | -        | 0.65         |                     |         |               |            |              |                           |           |        |           |              |
| 30, . .             | -       | 0.15          | 0.31       | -            | -                         | -         | -      | -        | -            |                     |         |               |            |              |                           |           |        |           |              |
| 31, . .             | 0.20    | 0.23          | 0.06       | 0.02         | -                         | 0.06      | 0.02   | -        | -            |                     |         |               |            |              |                           |           |        |           |              |
| TOTALS,             | 3.40    | 2.74          | 2.30       | 2.93         | 2.74                      | 2.01      | 2.19   | 3.16     | 3.71         | TOTALS,             | 6.35    | 7.50          | 6.89       | 8.15         | 8.31                      | 5.24      | 5.77   | 7.72      | 8.15         |

\* Precipitation included in that of following day.

† Average of two stations.

*Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected*  
— Continued.

March, 1893.

April, 1893.

| DAY<br>OF<br>MONTH. | Ludlow. | Gilbertville. | Fitchburg. | Framingham. | Chestnut Hill,<br>Boston. | Lawrence. | Salem. | Taunton.† | New Bedford. | DAY<br>OF<br>MONTH. | Ludlow. | Gilbertville. | Fitchburg. | Framingham. | Chestnut Hill,<br>Boston. | Lawrence. | Salem. | Taunton.† | New Bedford. |
|---------------------|---------|---------------|------------|-------------|---------------------------|-----------|--------|-----------|--------------|---------------------|---------|---------------|------------|-------------|---------------------------|-----------|--------|-----------|--------------|
| 1, .                | 0.20    | -             | 0.10       | -           | -                         | -         | -      | 0.24      | 0.00         | 1, .                | -       | -             | 0.01       | -           | -                         | -         | -      | -         | -            |
| 2, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 2, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 3, .                | 0.10    | 0.20          | -          | 0.03        | -                         | -         | -      | *         | *            | 3, .                | -       | -             | -          | -           | -                         | -         | -      | -         | *            |
| 4, .                | 0.10    | 0.25          | 0.08       | 0.40        | 0.20                      | 0.02      | 0.09   | 0.20      | 0.50         | 4, .                | 0.10    | 0.12          | 0.06       | 0.16        | 0.07                      | 0.08      | -      | 0.11      | 0.35         |
| 5, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 5, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 6, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 6, .                | 0.25    | 0.42          | 0.19       | 0.40        | 0.23                      | 0.13      | 0.33   | *         | 0.20         |
| 7, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 7, .                | 0.50    | 0.60          | 0.73       | *           | 0.53                      | *         | 0.29   | *         | 0.64         |
| 8, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 8, .                | 0.45    | 0.92          | 0.32       | 0.42        | 0.18                      | 0.81      | 0.18   | 1.23      | 0.31         |
| 9, .                | 0.00    | 0.70          | 0.50       | *           | *                         | *         | 0.83   | *         | *            | 9, .                | -       | -             | -          | 0.32        | 0.10                      | -         | 0.15   | -         | -            |
| 10, .               | 0.05    | -             | -          | 1.39        | 1.55                      | 0.61      | -      | *         | 3.61         | 10, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 11, .               | *       | -             | 0.03       | *           | *                         | *         | -      | *         | -            | 11, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 12, .               | 0.75    | 0.50          | 0.70       | 0.63        | 0.30                      | 0.36      | 0.12   | 3.77      | 0.29         | 12, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 13, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 13, .               | 0.10    | -             | 0.03       | 0.03        | -                         | -         | -      | *         | 0.10         |
| 14, .               | *       | -             | *          | *           | *                         | *         | -      | -         | -            | 14, .               | 0.15    | -             | 0.10       | *           | *                         | *         | 0.42   | *         | *            |
| 15, .               | 1.00    | 0.90          | 1.29       | 0.97        | 1.00                      | 1.09      | 0.78   | 0.58      | 0.34         | 15, .               | 0.65    | 0.52          | 0.17       | 0.71        | 0.73                      | 0.69      | 0.42   | 0.87      | 0.86         |
| 16, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 16, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 17, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 17, .               | -       | -             | -          | -           | -                         | -         | -      | -         | 0.02         |
| 18, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 18, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 19, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 19, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 20, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 20, .               | 0.40    | *             | 0.18       | *           | *                         | *         | *      | *         | *            |
| 21, .               | 0.15    | 0.30          | 0.04       | 0.04        | -                         | -         | 0.02   | *         | 0.06         | 21, .               | 0.70    | *             | 0.77       | 1.00        | 1.17                      | 0.71      | 1.29   | 0.94      | 1.42         |
| 22, .               | 0.10    | *             | -          | *           | *                         | -         | -      | *         | *            | 22, .               | 0.05    | 1.10          | 0.08       | -           | -                         | -         | -      | -         | 0.03         |
| 23, .               | 0.10    | 0.35          | 0.02       | 0.22        | 0.10                      | 0.02      | 0.04   | *         | 0.31         | 23, .               | -       | -             | -          | -           | 0.05                      | -         | -      | -         | -            |
| 24, .               | 0.10    | -             | -          | -           | -                         | -         | 0.07   | 0.41      | 0.29         | 24, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 25, .               | 0.03    | -             | -          | -           | -                         | 0.09      | -      | -         | -            | 25, .               | 0.10    | 0.10          | 0.02       | 0.11        | 0.14                      | 0.07      | 0.08   | 0.19      | 0.22         |
| 26, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 26, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 27, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 27, .               | 0.30    | *             | 0.12       | 0.18        | 0.17                      | 0.28      | *      | 0.31      | 0.37         |
| 28, .               | -       | -             | -          | -           | -                         | -         | -      | 0.04      | -            | 28, .               | 0.05    | 0.28          | -          | -           | -                         | -         | 0.18   | -         | -            |
| 29, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 29, .               | -       | -             | -          | -           | -                         | -         | -      | -         | 0.07         |
| 30, .               | 0.10    | 0.12          | 0.01       | -           | -                         | -         | -      | -         | 0.02         | 30, .               | -       | -             | -          | 0.06        | -                         | 0.02      | -      | -         | 0.04         |
| 31, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |                     |         |               |            |             |                           |           |        |           |              |
| TOTALS,             | 3.70    | 3.32          | 2.77       | 3.68        | 3.15                      | 2.19      | 1.95   | 5.20      | 5.55         | TOTALS,             | 3.80    | 4.05          | 2.78       | 3.39        | 3.32                      | 2.84      | 3.34   | 3.65      | 4.63         |

\* Precipitation included in that of following day.

† Average of two stations.

‡ Average of Ludlow, Amherst and Worcester stations.

*Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected*  
— Continued.

May, 1893.

June, 1893.

| DAY<br>OF<br>MONTH. | Ladlow. | Gilbertville. | Fitchburg. | Framingham. | Chestnut Hill,<br>Boston. | Lawrence. | Salem. | Taunton.† | New Bedford. | DAY<br>OF<br>MONTH. | Ladlow. | Gilbertville. | Fitchburg. | Framingham. | Chestnut Hill,<br>Boston. | Lawrence. | Salem. | Taunton.† | New Bedford. |
|---------------------|---------|---------------|------------|-------------|---------------------------|-----------|--------|-----------|--------------|---------------------|---------|---------------|------------|-------------|---------------------------|-----------|--------|-----------|--------------|
| 1, .                | 0.57    | 0.63          | 0.11       | *           | *                         | *         | 0.08   | *         | -            | 1, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 2, .                | 0.25    | 0.28          | 0.11       | 0.49        | *                         | *         | 0.21   | *         | *            | 2, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 3, .                | 0.27    | 0.33          | 0.70       | *           | *                         | *         | *      | *         | 0.78         | 3, .                | 0.06    | -             | -          | -           | -                         | -         | 0.02   | -         | 0.02         |
| 4, .                | 2.35    | 1.66          | 3.63       | 3.51        | 3.36                      | 3.11      | 2.47   | 3.20      | 2.12         | 4, .                | 0.06    | 0.06          | 0.01       | -           | -                         | -         | -      | -         | 0.04         |
| 5, .                | 0.10    | 0.03          | -          | -           | -                         | -         | 0.01   | -         | -            | 5, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 6, .                | -       | -             | 0.04       | 0.06        | -                         | 0.05      | 0.07   | 0.21      | 0.41         | 6, .                | 1.10    | 1.96          | 0.39       | 0.29        | -                         | 0.60      | 0.10   | -         | -            |
| 7, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 7, .                | 0.10    | -             | -          | -           | -                         | -         | -      | -         | -            |
| 8, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 8, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 9, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 9, .                | -       | -             | -          | -           | -                         | -         | -      | -         | *            |
| 10, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 10, .               | -       | -             | -          | -           | -                         | -         | -      | 0.15      | 0.18         |
| 11, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 11, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 12, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 12, .               | -       | -             | 0.06       | *           | -                         | -         | 0.04   | -         | -            |
| 13, .               | 0.10    | 0.09          | 0.38       | *           | 0.50                      | *         | *      | *         | *            | 13, .               | -       | -             | 0.04       | *           | *                         | *         | 0.06   | *         | 0.02         |
| 14, .               | 0.10    | 0.37          | 0.36       | 0.47        | -                         | 0.27      | 0.73   | 0.27      | 0.35         | 14, .               | -       | 0.07          | 0.18       | 0.90        | 0.55                      | 0.20      | 0.09   | 0.20      | 0.41         |
| 15, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 15, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 16, .               | 0.15    | 0.20          | 0.59       | *           | *                         | *         | *      | *         | *            | 16, .               | -       | -             | -          | -           | -                         | -         | -      | *         | 0.03         |
| 17, .               | 0.50    | 0.80          | 1.72       | 1.65        | 1.40                      | 1.70      | 1.61   | 1.22      | 1.23         | 17, .               | 0.12    | -             | 0.45       | 0.32        | 0.24                      | *         | *      | 0.27      | 0.21         |
| 18, .               | 0.12    | 0.03          | -          | 0.06        | -                         | 0.11      | 0.05   | -         | -            | 18, .               | -       | -             | -          | -           | -                         | 0.43      | 0.34   | -         | -            |
| 19, .               | -       | -             | -          | -           | -                         | -         | -      | -         | 0.03         | 19, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 20, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 20, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 21, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 21, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 22, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 22, .               | 1.02    | 1.30          | 1.20       | *           | -                         | *         | 0.33   | 1.08      | *            |
| 23, .               | 0.10    | *             | *          | 0.04        | -                         | -         | -      | -         | -            | 23, .               | 0.27    | 0.16          | 0.18       | *           | 1.60                      | *         | 2.12   | *         | 1.27         |
| 24, .               | -       | 0.20          | 0.11       | -           | -                         | -         | -      | 0.07      | 0.07         | 24, .               | -       | -             | 0.06       | 0.94        | 0.04                      | 1.51      | 0.21   | 0.59      | 0.95         |
| 25, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 25, .               | 0.50    | *             | -          | 0.02        | -                         | -         | -      | -         | -            |
| 26, .               | 0.10    | -             | -          | 0.06        | 0.03                      | -         | -      | *         | *            | 26, .               | 0.42    | 0.90          | 0.06       | -           | -                         | -         | -      | -         | -            |
| 27, .               | 0.30    | 0.22          | 0.50       | *           | 0.48                      | *         | *      | 0.07      | 0.06         | 27, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 28, .               | 0.10    | -             | -          | 0.61        | -                         | 0.31      | 0.53   | -         | 0.01         | 28, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 29, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 29, .               | 0.10    | 0.02          | -          | -           | -                         | -         | -      | -         | -            |
| 30, .               | 0.10    | -             | -          | -           | -                         | -         | -      | -         | -            | 30, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 31, .               | 0.05    | -             | -          | -           | -                         | -         | -      | -         | -            |                     |         |               |            |             |                           |           |        |           |              |
| TOTALS,             | 5.26    | 4.84          | 8.25       | 6.94        | 5.77                      | 5.55      | 5.76   | 5.04      | 5.06         | TOTALS,             | 3.73    | 4.46          | 2.66       | 2.47        | 2.33                      | 2.74      | 3.31   | 2.29      | 3.13         |

\* Precipitation included in that of following day.

† Average of two stations.



*Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected*  
— Continued.

July, 1892.

August, 1892.

| DAY<br>OF<br>MONTH. | Ludlow. | Gilbertville. | Fitchburg. | Framingham. | Chestnut Hill,<br>Boston. | Lawrence. | Salem. | Taunton.† | New Bedford. | DAY<br>OF<br>MONTH. | Ludlow. | Gilbertville. | Fitchburg. | Framingham. | Chestnut Hill,<br>Boston. | Lawrence. | Salem. | Taunton.† | New Bedford. |
|---------------------|---------|---------------|------------|-------------|---------------------------|-----------|--------|-----------|--------------|---------------------|---------|---------------|------------|-------------|---------------------------|-----------|--------|-----------|--------------|
| 1, .                | 0.05    | -             | -          | -           | -                         | -         | -      | -         | -            | 1, .                | -       | -             | 0.36       | -           | -                         | 0.47      | -      | 0.12      | 0.25         |
| 2, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 2, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 3, .                | 0.02    | -             | -          | -           | -                         | -         | -      | 0.18      | 0.35         | 3, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 4, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 4, .                | -       | -             | -          | *           | *                         | *         | *      | *         | *            |
| 5, .                | 0.50    | 0.06          | 0.14       | 0.38        | 0.24                      | 0.35      | *      | 0.47      | 0.87         | 5, .                | -       | 0.11          | 0.09       | 1.65        | 1.99                      | 0.89      | 2.48   | 2.87      | 1.44         |
| 6, .                | -       | 0.50          | 0.29       | -           | -                         | -         | 0.24   | -         | -            | 6, .                | 0.25    | 0.04          | -          | 0.42        | 1.48                      | 0.18      | *      | -         | -            |
| 7, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 7, .                | 0.05    | -             | -          | 0.19        | 0.36                      | 0.32      | 2.87   | 0.03      | -            |
| 8, .                | 0.20    | 0.19          | 0.10       | 0.06        | 0.07                      | 0.14      | -      | -         | -            | 8, .                | -       | -             | 1.28       | -           | -                         | -         | 0.38   | -         | -            |
| 9, .                | -       | -             | -          | -           | -                         | -         | -      | 0.02      | -            | 9, .                | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 10, .               | 0.05    | -             | -          | -           | -                         | -         | -      | -         | -            | 10, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 11, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 11, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 12, .               | 0.30    | 0.13          | 0.06       | 0.12        | 0.10                      | 0.08      | *      | *         | 0.06         | 12, .               | 0.02    | 0.02          | 0.79       | 0.03        | -                         | 0.77      | *      | -         | 0.03         |
| 13, .               | -       | 0.18          | -          | -           | -                         | -         | 0.02   | 0.28      | -            | 13, .               | 0.56    | -             | 0.18       | -           | -                         | -         | 0.17   | 0.07      | -            |
| 14, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 14, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 15, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 15, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 16, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 16, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 17, .               | 0.05    | -             | -          | -           | -                         | -         | -      | -         | -            | 17, .               | 0.10    | 0.20          | 0.19       | 0.03        | 0.09                      | *         | *      | 0.23      | 0.36         |
| 18, .               | -       | 0.15          | -          | 1.49        | 0.73                      | 0.21      | 0.03   | 0.55      | -            | 18, .               | 0.24    | 0.15          | 0.04       | -           | 0.04                      | 0.42      | 0.18   | -         | -            |
| 19, .               | -       | -             | 0.02       | -           | -                         | -         | -      | -         | -            | 19, .               | -       | -             | 0.02       | -           | -                         | -         | 0.02   | -         | -            |
| 20, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 20, .               | 0.10    | 0.20          | 0.20       | *           | *                         | 0.13      | 0.02   | *         | *            |
| 21, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 21, .               | 0.16    | 0.60          | 0.61       | 1.81        | 1.84                      | 0.95      | 1.48   | 2.65      | 2.74         |
| 22, .               | 0.20    | 0.22          | 0.21       | 0.26        | 0.67                      | 0.89      | 0.99   | *         | 0.17         | 22, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 23, .               | -       | -             | 0.24       | 0.09        | 0.16                      | 0.41      | 0.01   | 0.24      | -            | 23, .               | 0.02    | -             | -          | -           | -                         | *         | -      | -         | *            |
| 24, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 24, .               | 0.82    | 0.77          | 0.83       | 0.82        | 0.35                      | 0.50      | 0.24   | 0.35      | 0.36         |
| 25, .               | 0.06    | 0.38          | 0.11       | 0.23        | 0.10                      | 0.32      | *      | *         | 0.19         | 25, .               | -       | 0.04          | -          | -           | -                         | -         | -      | -         | -            |
| 26, .               | 0.12    | 0.51          | 0.32       | 0.21        | 0.03                      | 1.09      | 0.66   | 0.31      | 0.22         | 26, .               | 0.10    | 0.10          | -          | -           | -                         | -         | -      | -         | -            |
| 27, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 27, .               | -       | -             | 1.91       | -           | -                         | 0.03      | -      | -         | 0.02         |
| 28, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 28, .               | 0.10    | 0.20          | -          | -           | -                         | -         | -      | -         | -            |
| 29, .               | 0.22    | 0.32          | 0.03       | -           | -                         | 0.13      | -      | 0.07      | 0.08         | 29, .               | 0.78    | 0.97          | 1.04       | 0.43        | 0.39                      | 0.52      | 0.18   | 0.12      | 0.02         |
| 30, .               | -       | -             | -          | 0.06        | -                         | -         | -      | -         | -            | 30, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 31, .               | -       | -             | -          | 0.02        | -                         | -         | -      | -         | -            | 31, .               | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| TOTALS,             | 1.77    | 2.64          | 1.54       | 2.91        | 2.10                      | 3.48      | 1.95   | 2.10      | 1.96         | TOTALS,             | 3.10    | 3.40          | 7.58       | 5.38        | 6.53                      | 4.68      | 8.00   | 6.44      | 5.22         |

\* Precipitation included in that of following day.

† Average of two stations.

*Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected*  
— Continued.

September, 1893.

October, 1893.

| DAY<br>OF<br>MONTH. | Ludlow. | Gilbertville. | Fitchburg. | Framingham. | Chestnut Hill,<br>Boston. | Lawrence. | Salem. | Taunton.† | New Bedford. | DAY<br>OF<br>MONTH. | Ludlow. | Gilbertville. | Fitchburg. | Framingham. | Chestnut Hill,<br>Boston. | Lawrence. | Salem. | Taunton.† | New Bedford. |
|---------------------|---------|---------------|------------|-------------|---------------------------|-----------|--------|-----------|--------------|---------------------|---------|---------------|------------|-------------|---------------------------|-----------|--------|-----------|--------------|
| 1, . .              | -       | -             | -          | *           | *                         | *         | *      | *         | 0.72         | 1, . .              | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 2, . .              | 0.05    | -             | 0.04       | 0.29        | 0.36                      | 0.15      | 0.31   | 0.55      | -            | 2, . .              | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 3, . .              | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 3, . .              | -       | -             | -          | -           | -                         | -         | 0.05   | -         | -            |
| 4, . .              | -       | -             | 0.02       | -           | -                         | -         | -      | -         | -            | 4, . .              | -       | -             | 0.02       | 0.06        | -                         | -         | -      | -         | 0.04         |
| 5, . .              | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 5, . .              | -       | -             | -          | -           | -                         | 0.03      | -      | -         | -            |
| 6, . .              | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 6, . .              | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 7, . .              | 0.75    | 1.20          | 0.58       | 0.54        | 0.46                      | 0.83      | *      | -         | 0.14         | 7, . .              | 0.18    | 0.33          | 0.28       | 0.11        | -                         | 0.17      | -      | 0.03      | 0.03         |
| 8, . .              | 0.23    | -             | 0.02       | -           | -                         | -         | 0.47   | 0.13      | -            | 8, . .              | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 9, . .              | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 9, . .              | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 10, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 10, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 11, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 11, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 12, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 12, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 13, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 13, . .             | -       | -             | -          | -           | *                         | -         | -      | -         | -            |
| 14, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 14, . .             | 0.94    | 1.84          | 1.16       | 0.73        | 1.39                      | 0.72      | 0.68   | 0.74      | 0.62         |
| 15, . .             | 0.34    | 0.35          | 0.02       | 0.03        | 0.02                      | -         | -      | -         | 0.03         | 15, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 16, . .             | 0.48    | 0.56          | 0.41       | 0.63        | 0.56                      | 0.54      | 0.53   | 0.70      | 0.46         | 16, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 17, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 17, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 18, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 18, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 19, . .             | 0.11    | -             | 0.15       | 0.21        | 0.23                      | 0.09      | 0.07   | 0.23      | 0.47         | 19, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 20, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 20, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 21, . .             | -       | -             | 0.01       | -           | -                         | -         | -      | -         | -            | 21, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 22, . .             | -       | -             | 0.02       | -           | -                         | -         | -      | *         | 0.03         | 22, . .             | -       | -             | -          | *           | -                         | -         | -      | -         | -            |
| 23, . .             | 0.06    | 0.11          | -          | 0.03        | 0.05                      | 0.02      | -      | 0.06      | 0.04         | 23, . .             | 0.49    | 0.65          | 0.81       | *           | *                         | *         | *      | *         | 0.04         |
| 24, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 24, . .             | 0.95    | 1.90          | 1.51       | 2.27        | 2.02                      | 2.00      | 2.54   | 1.81      | 1.76         |
| 25, . .             | 0.10    | 0.22          | 0.25       | -           | 0.12                      | 0.10      | *      | 0.30      | 0.41         | 25, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 26, . .             | -       | -             | -          | -           | -                         | -         | 0.06   | -         | 0.22         | 26, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 27, . .             | -       | -             | -          | -           | -                         | -         | -      | *         | *            | 27, . .             | 0.10    | 0.06          | 0.05       | *           | *                         | *         | -      | -         | -            |
| 28, . .             | -       | -             | -          | -           | -                         | -         | -      | 0.15      | 0.50         | 28, . .             | 1.50    | 1.90          | 1.20       | 0.91        | 0.29                      | 0.84      | -      | 0.23      | 0.12         |
| 29, . .             | 0.30    | 0.15          | 0.05       | 0.07        | 0.05                      | 0.08      | -      | -         | -            | 29, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 30, . .             | -       | 0.03          | 0.07       | -           | -                         | -         | -      | 0.02      | 0.02         | 30, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| 31, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            | 31, . .             | -       | -             | -          | -           | -                         | -         | -      | -         | -            |
| TOTALS,             | 2.42    | 2.62          | 1.64       | 1.80        | 1.85                      | 1.81      | 1.44   | 2.20      | 3.04         | TOTALS,             | 4.16    | 6.68          | 5.03       | 4.08        | 3.70                      | 3.76      | 3.27   | 2.81      | 2.61         |

\* Precipitation included in that of following day.

† Average of two stations.

*Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected*  
— Concluded.

November, 1893.

December, 1893.

| DAY OF MONTH. | Ludlow. | Gilbertville. | Fitchburg. | Framingham. | Chestnut Hill, Boston. | Lawrence. | Salem. | Taunton. | New Bedford. | DAY OF MONTH. | Ludlow. | Gilbertville. | Fitchburg. | Framingham. | Chestnut Hill, Boston. | Lawrence. | Salem. | Taunton. | New Bedford. |
|---------------|---------|---------------|------------|-------------|------------------------|-----------|--------|----------|--------------|---------------|---------|---------------|------------|-------------|------------------------|-----------|--------|----------|--------------|
| 1, .          | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 1, .          | 0.28    | 0.35          | 0.30       | 0.40        | 0.39                   | 0.33      | 0.41   | 0.52     | 0.56         |
| 2, .          | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 2, .          | 0.10    | -             | -          | -           | -                      | -         | -      | -        | -            |
| 3, .          | 0.04    | 0.06          | 0.01       | -           | -                      | 0.01      | -      | -        | 0.02         | 3, .          | 1.87    | *             | 1.40       | *           | *                      | *         | 1.20   | *        | 0.15         |
| 4, .          | 0.34    | 0.40          | 0.41       | *           | *                      | -         | *      | *        | *            | 4, .          | -       | 2.00          | 0.78       | 1.45        | 1.56                   | 2.96      | 0.39   | 1.57     | 1.84         |
| 5, .          | 0.31    | 0.30          | 0.22       | 0.81        | 0.71                   | 0.48      | 0.60   | 1.36     | 0.93         | 5, .          | 0.15    | *             | 0.66       | 0.70        | 0.67                   | *         | *      | 1.96     | *            |
| 6, .          | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 6, .          | -       | 0.30          | -          | -           | -                      | 0.63      | 1.05   | -        | 1.00         |
| 7, .          | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 7, .          | -       | -             | -          | -           | -                      | -         | -      | -        | -            |
| 8, .          | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 8, .          | -       | -             | -          | -           | -                      | -         | -      | -        | -            |
| 9, .          | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 9, .          | 0.25    | 0.30          | 0.10       | 0.42        | *                      | *         | *      | 0.47     | *            |
| 10, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 10, .         | -       | -             | -          | -           | 0.35                   | 0.29      | 0.34   | -        | 0.41         |
| 11, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 11, .         | -       | -             | -          | 0.04        | -                      | -         | -      | -        | -            |
| 12, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 12, .         | 0.05    | 0.18          | 0.09       | -           | -                      | 0.08      | 0.08   | -        | -            |
| 13, .         | 0.03    | 0.09          | -          | -           | -                      | -         | -      | -        | 0.03         | 13, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            |
| 14, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 14, .         | 0.10    | -             | 0.09       | -           | *                      | *         | *      | *        | *            |
| 15, .         | 0.13    | 0.20          | 0.10       | 0.18        | 0.19                   | 0.10      | 0.18   | 0.37     | 0.36         | 15, .         | 0.45    | *             | 0.30       | -           | *                      | *         | 0.42   | 0.74     | 1.20         |
| 16, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 16, .         | 0.44    | *             | 0.95       | -           | *                      | *         | 0.21   | *        | *            |
| 17, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 17, .         | 0.31    | 1.80          | -          | 1.64        | 1.54                   | 1.22      | 0.73   | 0.83     | 1.17         |
| 18, .         | -       | -             | -          | -           | -                      | -         | -      | 0.02     | 0.04         | 18, .         | -       | -             | -          | 0.04        | -                      | -         | -      | -        | -            |
| 19, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 19, .         | 0.02    | 0.30          | 0.06       | -           | 0.03                   | 0.04      | 0.08   | 0.15     | 0.11         |
| 20, .         | -       | -             | -          | -           | 0.02                   | 0.08      | -      | -        | -            | 20, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            |
| 21, .         | -       | -             | -          | *           | -                      | -         | -      | -        | -            | 21, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            |
| 22, .         | 0.47    | 0.57          | 0.92       | 0.70        | 0.65                   | 0.76      | 0.65   | 0.63     | 0.62         | 22, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            |
| 23, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 23, .         | 0.14    | 0.17          | 0.06       | 0.06        | 0.08                   | 0.05      | 0.02   | -        | 0.02         |
| 24, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 24, .         | 0.02    | -             | -          | -           | -                      | -         | -      | -        | -            |
| 25, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 25, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            |
| 26, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 26, .         | -       | -             | -          | -           | -                      | -         | -      | -        | 0.02         |
| 27, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 27, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            |
| 28, .         | 0.30    | 0.78          | 0.82       | 0.54        | 0.43                   | 0.30      | 0.34   | 0.59     | 0.71         | 28, .         | 0.05    | -             | 0.01       | -           | -                      | 0.01      | -      | -        | 0.02         |
| 29, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 29, .         | 0.12    | 0.18          | 0.06       | 0.05        | 0.05                   | 0.11      | 0.09   | 0.10     | 0.07         |
| 30, .         | -       | -             | -          | -           | -                      | -         | -      | -        | -            | 30, .         | 0.10    | -             | 0.05       | -           | *                      | -         | -      | 0.29     | 0.07         |
| TOT.,         | 1.62    | 2.40          | 2.48       | 2.23        | 2.00                   | 1.82      | 1.77   | 2.97     | 2.71         | 31, .         | 0.11    | 0.10          | 0.04       | 0.14        | 0.24                   | 0.12      | 0.20   | 0.09     | 0.31         |
| TOT.,         | 4.56    | 5.68          | 4.95       | 4.94        | 4.91                   | 5.84      | 5.22   | 6.72     | 6.95         | TOT.,         | 43.87   | 50.34         | 48.86      | 48.90       | 46.71                  | 41.96     | 43.97  | 50.30    | 52.72        |

TOTALS FOR YEAR,

\* Precipitation included in that of following day.

## FLOW OF STREAMS.

The flow of the streams of the State during the year 1893, as indicated by the flow of Sudbury River, was a very little less than the average for the past nineteen years, but the distribution was very uneven. The flow was above the average in March, April and May, in the latter month being nearly twice as great as that recorded in the same month for any previous year, but in all the remaining months the flow was below the average, and from June to November, inclusive, was the smallest since 1887.

The effect of this distribution of the flow was the opposite of that of the previous year. In 1893 the drought was felt most by the cities and towns deriving their supply from large watersheds, with comparatively small storage, from which water usually runs to waste in the spring; while those communities taking their supply from large ponds fed by comparatively small watersheds experienced no unusual inconvenience, owing to the large amount of water collected during the spring months.

In order to show the relation between the flow of the Sudbury River during each month of 1893 and the normal flow of the same river, as deduced from fifteen years' observations from 1879 to 1893, inclusive, the following table has been prepared. The area of the watershed of the Sudbury River above the point of measurement is 75.2 square miles.

*Table showing the Average Monthly Flow of Sudbury River for the Year 1893, in Cubic Feet per Second per Square Mile of Drainage Area, also Departures from the Normal Flow.*

| MONTH.               | NORMAL FLOW.                                 | ACTUAL FLOW<br>IN 1893.                      | EXCESS OR DEFICIENCY.                        |
|----------------------|----------------------------------------------|----------------------------------------------|----------------------------------------------|
|                      | Cubic Feet per<br>Second per<br>Square Mile. | Cubic Feet per<br>Second per<br>Square Mile. | Cubic Feet per<br>Second per<br>Square Mile. |
| January, . . . . .   | 2.115                                        | 0.670                                        | -1.445                                       |
| February, . . . . .  | 3.190                                        | 2.386                                        | -0.804                                       |
| March, . . . . .     | 4.159                                        | 5.021                                        | +0.862                                       |
| April, . . . . .     | 2.951                                        | 3.288                                        | +0.337                                       |
| May, . . . . .       | 1.807                                        | 4.461                                        | +2.654                                       |
| June, . . . . .      | 0.736                                        | 0.680                                        | -0.056                                       |
| July, . . . . .      | 0.279                                        | 0.245                                        | -0.034                                       |
| August, . . . . .    | 0.430                                        | 0.279                                        | -0.151                                       |
| September, . . . . . | 0.432                                        | 0.168                                        | -0.264                                       |
| October, . . . . .   | 0.790                                        | 0.343                                        | -0.447                                       |
| November, . . . . .  | 1.119                                        | 0.493                                        | -0.626                                       |
| December, . . . . .  | 1.422                                        | 1.233                                        | -0.189                                       |
| AVERAGE, . . . . .   | 1.611                                        | 1.604                                        | -0.007                                       |

The next table shows the weekly fluctuations, during 1893, in the flow of the two streams most carefully measured, namely, the Sudbury and the Merrimack. The flow of these streams, particularly the Sudbury, will serve to indicate the condition of other streams in eastern Massachusetts.

*Table showing the Average Weekly Flow of the Sudbury and Merrimack Rivers, in Cubic Feet per Second per Square Mile of Drainage Area, for the Year 1893.*

| WEEK ENDING SUNDAY. | SUDBURY RIVER.<br>Cubic Feet<br>per<br>Second<br>per Square<br>Mile. | MERRIMACK RIVER.<br>Cubic Feet<br>per<br>Second<br>per Square<br>Mile. | WEEK ENDING SUNDAY. | SUDBURY RIVER.<br>Cubic Feet<br>per<br>Second<br>per Square<br>Mile. | MERRIMACK RIVER.<br>Cubic Feet<br>per<br>Second<br>per Square<br>Mile. |
|---------------------|----------------------------------------------------------------------|------------------------------------------------------------------------|---------------------|----------------------------------------------------------------------|------------------------------------------------------------------------|
| Jan. 1, . . . .     | 0.514                                                                | 0.837                                                                  | July 2, . . . .     | 0.516                                                                | 0.900                                                                  |
| 8, . . . .          | 1.132                                                                | 1.017                                                                  | 9, . . . .          | 0.312                                                                | 0.604                                                                  |
| 15, . . . .         | 0.626                                                                | 0.610                                                                  | 16, . . . .         | 0.211                                                                | 0.503                                                                  |
| 22, . . . .         | 0.400                                                                | 0.626                                                                  | 23, . . . .         | 0.253                                                                | 0.470                                                                  |
| 29, . . . .         | 0.412                                                                | 0.470                                                                  | 30, . . . .         | 0.179                                                                | 0.535                                                                  |
| Feb. 5, . . . .     | 0.586                                                                | 0.487                                                                  | Aug. 6, . . . .     | 0.275                                                                | 0.441                                                                  |
| 12, . . . .         | 4.937                                                                | 1.067                                                                  | 13, . . . .         | 0.251                                                                | 0.460                                                                  |
| 19, . . . .         | 2.580                                                                | 1.678                                                                  | 20, . . . .         | 0.181                                                                | 0.437                                                                  |
| 26, . . . .         | 1.237                                                                | 0.982                                                                  | 27, . . . .         | 0.389                                                                | 0.661                                                                  |
| Mar. 5, . . . .     | 1.248                                                                | 0.844                                                                  | Sept. 3, . . . .    | 0.234                                                                | 1.000                                                                  |
| 12, . . . .         | 2.805                                                                | 0.936                                                                  | 10, . . . .         | 0.184                                                                | 0.514                                                                  |
| 19, . . . .         | 10.061                                                               | 4.126                                                                  | 17, . . . .         | 0.175                                                                | 0.481                                                                  |
| 26, . . . .         | 5.164                                                                | 2.569                                                                  | 24, . . . .         | 0.128                                                                | 0.617                                                                  |
| Apr. 2, . . . .     | 4.228                                                                | 3.239                                                                  | Oct. 1, . . . .     | 0.162                                                                | 0.515                                                                  |
| 9, . . . .          | 3.610                                                                | 3.593                                                                  | 8, . . . .          | 0.165                                                                | 0.515                                                                  |
| 16, . . . .         | 3.472                                                                | 4.630                                                                  | 15, . . . .         | 0.184                                                                | 0.534                                                                  |
| 23, . . . .         | 3.350                                                                | 3.916                                                                  | 22, . . . .         | 0.197                                                                | 0.777                                                                  |
| 30, . . . .         | 2.677                                                                | 3.490                                                                  | 29, . . . .         | 0.783                                                                | 1.375                                                                  |
| May 7, . . . .      | 7.854                                                                | 7.009                                                                  | Nov. 5, . . . .     | 0.538                                                                | 1.515                                                                  |
| 14, . . . .         | 4.209                                                                | 5.087                                                                  | 12, . . . .         | 0.566                                                                | 0.822                                                                  |
| 21, . . . .         | 5.003                                                                | 5.808                                                                  | 19, . . . .         | 0.425                                                                | 0.702                                                                  |
| 28, . . . .         | 2.140                                                                | 3.000                                                                  | 26, . . . .         | 0.453                                                                | 0.742                                                                  |
| June 4, . . . .     | 1.161                                                                | 1.679                                                                  | Dec. 3, . . . .     | 0.645                                                                | 1.063                                                                  |
| 11, . . . .         | 0.636                                                                | 1.206                                                                  | 10, . . . .         | 1.091                                                                | 1.194                                                                  |
| 18, . . . .         | 0.676                                                                | 1.011                                                                  | 17, . . . .         | 0.900                                                                | 1.200                                                                  |
| 25, . . . .         | 0.657                                                                | 0.929                                                                  | 24, . . . .         | 1.091                                                                | 0.716                                                                  |
|                     |                                                                      |                                                                        | 31, . . . .         | 1.991                                                                | 1.000                                                                  |

In the annual report of the State Board of Health for the year 1890 (pages 338 to 340) a table was printed giving records of the rainfall upon the Sudbury River watershed, and its yield, expressed in inches in depth upon the watershed (inches of rainfall collected), for the sixteen years from 1875 to 1890 inclusive. The corresponding records for the years 1891 and 1892, as taken from the annual reports of the Boston Water Board, were given in the annual report for 1892. In the following table is given the record for 1893, together with the average of the records for the whole nineteen years.

*Rainfall Received and Collected on the Sudbury River Watershed.*

| MONTH.                   | 1893.     |                        |                         | MEAN FOR 19 YEARS,<br>1875-1893. |                        |                         |
|--------------------------|-----------|------------------------|-------------------------|----------------------------------|------------------------|-------------------------|
|                          | Rainfall. | Rainfall<br>Collected. | Per Cent.<br>Collected. | Rainfall.                        | Rainfall<br>Collected. | Per Cent.<br>Collected. |
| January, . . . . .       | 2.925     | 0.773                  | 26.44                   | 4.351                            | 2.227                  | 51.18                   |
| February, . . . . .      | 8.195     | 2.485                  | 30.32                   | 4.292                            | 3.184                  | 74.18                   |
| March, . . . . .         | 3.670     | 5.789                  | 157.74                  | 4.603                            | 5.133                  | 111.51                  |
| April, . . . . .         | 3.605     | 3.668                  | 101.75                  | 3.235                            | 3.540                  | 109.43                  |
| May, . . . . .           | 6.610     | 5.143                  | 77.81                   | 3.445                            | 2.125                  | 61.68                   |
| June, . . . . .          | 2.390     | 0.759                  | 31.88                   | 2.983                            | 0.848                  | 28.43                   |
| July, . . . . .          | 2.570     | 0.282                  | 10.96                   | 3.723                            | 0.333                  | 8.94                    |
| August, . . . . .        | 5.415     | 0.322                  | 5.95                    | 4.327                            | 0.523                  | 12.09                   |
| September, . . . . .     | 1.735     | 0.187                  | 10.75                   | 3.088                            | 0.436                  | 14.12                   |
| October, . . . . .       | 4.065     | 0.395                  | 9.72                    | 4.193                            | 0.909                  | 21.68                   |
| November, . . . . .      | 2.195     | 0.550                  | 25.07                   | 4.042                            | 1.485                  | 36.74                   |
| December, . . . . .      | 4.860     | 1.421                  | 29.23                   | 3.633                            | 1.811                  | 49.85                   |
| TOTALS AND AVERAGES, . . | 48.225    | 21.774                 | 45.15                   | 45.915                           | 22.554                 | 49.12                   |

The Sudbury River records are particularly valuable as a basis for estimating the yield of other watersheds in Massachusetts, both on account of the accuracy with which the measurements have been made during the whole nineteen years, and the absence of abnormal conditions which would unfavorably affect the results. It is therefore thought advisable to publish in the following table those portions of the records relating to the yield of this watershed for each of the nineteen years; and in doing so the flow from the watershed is expressed in gallons per day per square mile, instead of inches in depth of rainfall collected, in order to render the table more convenient for use in estimating the probable yield of watersheds used as sources of water supply.

*Yield of the Sudbury River Watershed\* in Gallons Per Day Per Square Mile.*

| MONTH.                         | 1875.     | 1876.     | 1877.     | 1878.     | 1879.     | 1880.     | 1881.     |
|--------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| January, . . . . .             | 103,000   | 643,000   | 658,000   | 1,810,000 | 700,000   | 1,121,000 | 415,000   |
| February, . . . . .            | 1,496,000 | 1,368,000 | 949,000   | 2,465,000 | 1,711,000 | 1,787,000 | 1,548,000 |
| March, . . . . .               | 1,604,000 | 4,435,000 | 4,813,000 | 3,507,000 | 2,330,000 | 1,374,000 | 4,004,000 |
| April, . . . . .               | 3,049,000 | 3,292,000 | 2,394,000 | 1,626,000 | 3,116,000 | 1,168,000 | 1,546,000 |
| May, . . . . .                 | 1,188,000 | 1,139,000 | 1,391,000 | 1,394,000 | 1,114,000 | 514,000   | 965,000   |
| June, . . . . .                | 870,000   | 222,000   | 567,000   | 506,000   | 413,000   | 176,000   | 1,538,000 |
| July, . . . . .                | 821,000   | 183,000   | 202,000   | 128,000   | 158,000   | 177,000   | 276,000   |
| August, . . . . .              | 396,000   | 405,000   | 121,000   | 475,000   | 395,000   | 119,000   | 148,000   |
| September, . . . . .           | 207,000   | 184,000   | 60,000    | 160,000   | 141,000   | 80,000    | 197,000   |
| October, . . . . .             | 646,000   | 234,000   | 632,000   | 516,000   | 71,000    | 101,000   | 186,000   |
| November, . . . . .            | 1,302,000 | 1,088,000 | 1,418,000 | 1,093,000 | 206,000   | 205,000   | 395,000   |
| December, . . . . .            | 584,000   | 454,000   | 1,289,000 | 3,177,000 | 462,000   | 175,000   | 775,000   |
| Average for whole year, . .    | 972,000   | 1,135,000 | 1,214,000 | 1,452,000 | 894,000   | 578,000   | 979,000   |
| Av'ge for driest six months, . | 574,000   | 384,000   | 502,000   | 532,000   | 230,000   | 143,000   | 330,000   |

| MONTH.                         | 1882.     | 1883.     | 1884.     | 1885.     | 1886.     | 1887.     | 1888.     |
|--------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| January, . . . . .             | 1,241,000 | 335,000   | 995,000   | 1,235,000 | 1,461,000 | 2,589,000 | 1,053,000 |
| February, . . . . .            | 2,403,000 | 1,033,000 | 2,842,000 | 1,354,000 | 4,800,000 | 2,820,000 | 1,951,000 |
| March, . . . . .               | 2,839,000 | 1,611,000 | 3,785,000 | 1,672,000 | 2,059,000 | 2,868,000 | 3,237,000 |
| April, . . . . .               | 867,000   | 1,350,000 | 2,853,000 | 1,815,000 | 1,947,000 | 2,620,000 | 2,645,000 |
| May, . . . . .                 | 1,292,000 | 938,000   | 1,030,000 | 1,336,000 | 720,000   | 1,009,000 | 1,632,000 |
| June, . . . . .                | 529,000   | 300,000   | 417,000   | 428,000   | 203,000   | 414,000   | 422,000   |
| July, . . . . .                | 86,000    | 115,000   | 224,000   | 62,000    | 115,000   | 114,000   | 117,000   |
| August, . . . . .              | 55,000    | 78,000    | 257,000   | 240,000   | 94,000    | 214,000   | 380,000   |
| September, . . . . .           | 306,000   | 91,000    | 44,000    | 121,000   | 118,000   | 111,000   | 1,155,000 |
| October, . . . . .             | 299,000   | 186,000   | 83,000    | 336,000   | 146,000   | 190,000   | 1,099,000 |
| November, . . . . .            | 210,000   | 205,000   | 175,000   | 1,178,000 | 673,000   | 368,000   | 2,758,000 |
| December, . . . . .            | 314,000   | 193,000   | 925,000   | 1,174,000 | 1,020,000 | 643,000   | 3,043,000 |
| Average for whole year, . .    | 862,000   | 533,000   | 1,129,000 | 901,000   | 1,087,000 | 1,154,000 | 1,697,000 |
| Av'ge for driest six months, . | 211,000   | 145,000   | 200,000   | 391,000   | 223,000   | 234,000   | 953,000   |

| MONTH.                         | 1889.     | 1890.     | 1891.     | 1892.     | 1893.     | Mean for 19<br>Years,<br>1875-1893,<br>Inclusive. |
|--------------------------------|-----------|-----------|-----------|-----------|-----------|---------------------------------------------------|
| January, . . . . .             | 2,782,000 | 1,254,000 | 3,018,000 | 1,870,000 | 433,000   | 1,248,000                                         |
| February, . . . . .            | 1,195,000 | 1,629,000 | 3,486,000 | 943,000   | 1,542,000 | 1,958,000                                         |
| March, . . . . .               | 1,339,000 | 3,643,000 | 4,453,000 | 1,955,000 | 3,245,000 | 2,879,000                                         |
| April, . . . . .               | 1,410,000 | 1,875,000 | 2,397,000 | 871,000   | 2,125,000 | 2,051,000                                         |
| May, . . . . .                 | 880,000   | 1,366,000 | 582,000   | 1,259,000 | 2,883,000 | 1,191,000                                         |
| June, . . . . .                | 653,000   | 668,000   | 414,000   | 428,000   | 440,000   | 491,000                                           |
| July, . . . . .                | 633,000   | 108,000   | 149,000   | 214,000   | 158,000   | 186,000                                           |
| August, . . . . .              | 1,432,000 | 132,000   | 163,000   | 280,000   | 191,000   | 293,000                                           |
| September, . . . . .           | 824,000   | 458,000   | 203,000   | 229,000   | 108,000   | 252,000                                           |
| October, . . . . .             | 1,230,000 | 2,272,000 | 210,000   | 128,000   | 221,000   | 510,000                                           |
| November, . . . . .            | 1,941,000 | 1,215,000 | 305,000   | 697,000   | 319,000   | 860,000                                           |
| December, . . . . .            | 2,241,000 | 997,000   | 544,000   | 485,000   | 797,000   | 1,018,000                                         |
| Average for whole year, . .    | 1,383,000 | 1,285,000 | 1,315,000 | 781,000   | 1,037,000 | 1,073,000                                         |
| Av'ge for driest six months, . | 944,000   | 747,000   | 239,000   | 327,000   | 237,000   | 397,000                                           |

\* The area of the Sudbury River watershed used in making up these records included water surfaces amounting to about one per cent. of the whole area, from 1875 to 1878 inclusive, and subsequently increasing by the construction of storage reservoirs to about three per cent. in 1886. The watershed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

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ON THE  
AMOUNT AND CHARACTER  
OF  
ORGANIC MATTER IN SOILS  
AND ITS BEARING ON THE  
STORAGE OF WATER IN RESERVOIRS.

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By THOMAS M. DROWN, M.D., CHEMIST OF THE BOARD.

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# ON THE AMOUNT AND CHARACTER OF ORGANIC MATTER IN SOILS AND ITS BEARING ON THE STORAGE OF WATER IN RESERVOIRS.

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Many statements have been made in previous reports of the Board, concerning the injurious effect on impounded water of the organic matter in the bottoms and sides of reservoirs, and great stress has been laid on the importance of removing all vegetation, as well as the upper layers of the soil, before filling a new basin with water.\*

In order to determine in any case just how far it is necessary to go in the removal of the surface soil, a knowledge of the composition of the soil, based on chemical analysis, is a much surer guide than the unaided eye. It is not merely a question of the effective cleaning of the bottom and sides of the reservoir, but also of avoiding the expense involved in stripping the soil to a greater depth than is necessary. In connection with the investigations of the State Board of Health relative to a water supply for the city of Boston and its suburbs, surveys have been made for an immense storage reservoir on the south branch of the Nashua River above Clinton, and it was thought desirable that a thorough knowledge of the character of the soil should be obtained as a basis for determining the amount which it would be necessary to remove to obtain a clean bottom and sides practically free from organic matter. Samples of soils, representing sections of the ground to a depth of three feet, were taken at nine places in Clinton, Sterling, West Boylston, and Boylston, and in one case at the bottom of a mill pond.

Each of these nine sections were divided into six or seven samples for analysis, the upper portion being divided into thin layers of two to three inches, the lower portions, with less organic matter, into layers of six inches to one foot in depth.

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\* Compare special report upon the examination of water supplies, 1890, pages 748, 772, 773; report for 1891, page 381.

The amount of organic matter in these samples was determined (after careful drying to a constant weight at 100° C.) by heating the samples to a bright red heat. The loss on ignition thus obtained represents approximately the organic matter in the samples. But in order to get a better knowledge of the character of this organic matter, the amounts of carbon and of nitrogen were also determined in each sample — the former by combustion in oxygen, the latter by the Kjeldahl method. In series 9 and 10, the amount of hydrogen was also determined.\*

Owing to the heterogeneous character of many of the samples, composed often of a mixture of soil, roots and large stones, it is sometimes extremely difficult to get a sample for analysis that shall fairly represent the layer in question. Perhaps some of the apparent irregularities in the results may be due to this cause. But though this difficulty is inherent in the investigation it is not believed to seriously affect the results, or the conclusions drawn from them.

The results obtained in the analyses of the nine sections of soil, and the deposit from the bottom of the mill pond, are given in the accompanying tables. The largest amount of organic matter found was from a swamp at the head of Boylston Mill Pond (Series 7), and the next largest in amount from the hillside near the site of the proposed dam (Series 4). The other series, from very dissimilar ground, did not differ very widely in the amount of organic matter present, although they included both unwooded and uncultivated land and wooded and manured pasture land. But in all the series there is usually a rapid falling off in the amount of the organic matter below a depth of nine to eleven inches. At the depth of three feet the amount of organic matter, as shown by the loss on ignition, in no case reaches two per cent., and in the majority of the cases it is below one per cent. The mud taken from the bottom of the Mill Pond at different points contained very variable amounts of organic matter, from almost nothing at one place in the shallow portion to nearly 15 per cent. in the deeper portion.

It was thought that the relation of the amount of nitrogen to the amount of carbon in the organic matter might throw some light on its character and its likelihood to undergo decomposition. This relation is given to the column headed  $\frac{C}{N}$ . The only series in which the nitrogen ratio is noticeably higher than the rest is No. 5, from

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\* All the analyses in this investigation were made by Miss Elizabeth Mason.

low pasture land. Series Nos. 4 and 6, both from hillsides, show a noticeably high carbon ratio, and the others are not very dissimilar in their proportion of carbon to nitrogen.

An attempt was made to imitate the conditions which would obtain if the reservoir should be filled with water without removing the soil, in order to determine what would be the effect of each of the soils examined on water in contact with it. It is obvious that no laboratory experiment could exactly reproduce the conditions which would exist in a reservoir. Thus it would not be easy to imitate the period of long stagnation of the water during the summer, when the deeper layers of the water are in contact with the soil, without an opportunity to get a fresh supply of oxygen from the air. Still it was thought that some idea of the effect of the different soils on the water could be obtained by treating the samples with water for a definite time, and then examining the solutions thus obtained with respect to the character of the organic matter dissolved. In order to hasten the action of the water on the soils, it was heated to 65° C., and the time of contact at this temperature was six hours. The waters were then filtered and the filtrate examined by the usual methods used in the sanitary analysis of water. After standing one week the waters were again tested for free ammonia, to ascertain the amount of decomposition which had gone on in this time, thus obtaining information as to the character of the organic matter dissolved. The *actual amounts* of organic matter found in these solutions, as indicated by the albuminoid ammonia and oxygen consumed, are not especially significant, since they would probably have been very different if another temperature or a greater or less time of treatment had been adopted. But a comparison of the amounts dissolved from the soils in each series, and a comparison of the series with each other, yield information as to the relative facility with which each of the samples examined give up organic matter to water with which it comes in contact.

In the various experiments tried the proportion of soil to water differed, and in some cases distilled water was used and in others Cochituate water. But in the tables the results of series 1 to 8 have been calculated to represent the effect of the treatment of 100 grams of soil with two litres of pure water at 65° C. for six hours. In series 9 and 10 no heat was employed. In these experiments 250 grams of each sample were placed in a bottle with two litres of pure distilled water. After one week, one litre of this water was filtered

off and analyzed, and at the end of the second week the remaining water was examined.

In comparing these tables of analyses of the waters with the corresponding tables giving the percentage determinations of loss on ignition, carbon and nitrogen, a general agreement will be noticed; that is to say, the samples containing the most organic matter give, as a rule, the most concentrated solutions of organic matter. But the analyses do not indicate more than a very general correspondence of this kind. It will also be noted that the amount of decomposition going on in these solutions, indicated by the increase of free ammonia on standing one week, is, in general, also proportional to the amount of organic matter present. The most notable increase in the free ammonia is generally in the solutions prepared from the surface samples. In solutions from the deeper samples there is generally a decrease of free ammonia indicating doubtless its oxidation to nitrates. The samples from the bottom of the Mill Pond (series 8) give solutions which have little or no tendency to develop free ammonia. This might be expected from the fact that the organic matter they contain has long been in contact with water.

The effect of the soil on the color of water is given both for colorless distilled water, and for Cochituate water having an original color of about 0.55 on the scale used in the analyses of the State Board of Health. In these color determinations the water was not heated, and the length of time of contact with the soil was about 18 hours. It will be noticed that in some cases the deeper samples actually diminished the color of the Cochituate water.

As a preliminary conclusion, based on the facts determined in this investigation, it may be said that the effect of the organic matter in these various soils on the water in contact with them is simply a question of its amount, and that its origin and composition seem to be without marked influence. The watershed from which the samples were taken is very sparsely populated, and the organic matter in all cases is mainly of vegetable origin.

It is probable, therefore, that we need only concern ourselves with the amount of organic matter in a soil of this character in determining the necessity of its removal, and as a provisional standard we may perhaps fix 1.5 to 2 per cent. of organic matter, as determined by the loss on ignition of the sample dried at 100° C., as the permissible limit of organic matter that may be allowed to remain on the bottom and sides of a reservoir.

## SERIES 1.

*From a Cornfield One-quarter Mile below Clarendon Mills, West Boylston. Cultivated Fertilized Ground in Bottoms. Samples taken from Surface to Three Feet below Surface. All Samples dried at 100°C.*

|                                           | Loss<br>on Ignition.<br>(Per Cent.) | Carbon.<br>(Per Cent.) | Nitrogen.<br>(Per Cent.) | Ratio.<br>$\frac{c}{n}$ |
|-------------------------------------------|-------------------------------------|------------------------|--------------------------|-------------------------|
| 1a. Surface to 2 in. below, . . . .       | 8.54                                | 5.12                   | 0.47                     | 10.9                    |
| 1b. 2 in. to 4 in. below surface, . . .   | 6.83                                | 3.55                   | 0.21                     | 16.9                    |
| 1c. 4 in. to 6 in. below surface, . . .   | 7.43                                | 3.47                   | 0.30                     | 11.5                    |
| 1d. 6 in. to 9 in. below surface, . . .   | 4.27                                | 2.03                   | 0.21                     | 9.7                     |
| 1e. 9 in. to 14 in. below surface, . . .  | 1.87                                | 0.26                   | 0.04                     | 6.5                     |
| 1f. 14 in. to 20 in. below surface, . . . | 1.07                                | 0.16                   | 0.02                     | 8.0                     |
| 1g. 3 feet below surface, . . . . .       | 0.78                                | 0.15                   | 0.05                     | 3.0                     |

*Sanitary Analysis of Water with which the Soils had been treated as described.*

[Parts per 100,000.]

|                                       | Free<br>Ammonia. | Free<br>Ammonia<br>after<br>Standing<br>One Week. | Albuminoid<br>Ammonia. | Oxygen<br>Consumed. | Color with<br>Distilled<br>Water. | Effect<br>of Soils on<br>Color of<br>Cochineate<br>Water of<br>Color 0.55. |
|---------------------------------------|------------------|---------------------------------------------------|------------------------|---------------------|-----------------------------------|----------------------------------------------------------------------------|
| 1a. Surface to 2 in. below, . . .     | 0.0343           | 0.1107                                            | 0.1914                 | 2.2368              | Not det'd.                        | Not det'd.                                                                 |
| 1b. 2 in. to 4 in. below surface, .   | 0.0424           | 0.0984                                            | 0.1437                 | 2.0637              | "                                 | "                                                                          |
| 1c. 4 in. to 6 in. below surface, .   | 0.0317           | 0.0913                                            | 0.1538                 | 2.5290              | "                                 | "                                                                          |
| 1d. 6 in. to 9 in. below surface, .   | 0.0317           | 0.0359                                            | 0.0881                 | 0.9733              | "                                 | "                                                                          |
| 1e. 9 in. to 14 in. below surface, .  | 0.0212           | 0.0076                                            | 0.0351                 | 0.4947              | "                                 | "                                                                          |
| 1f. 14 in. to 20 in. below surface, . | 0.0194           | 0.0076                                            | 0.0189                 | 0.2515              | "                                 | "                                                                          |
| 1g. 3 feet below surface, . . .       | 0.0229           | 0.0374                                            | 0.0105                 | 0.2763              | "                                 | "                                                                          |

### SERIES 2.

*From a very Steep Slope One-quarter Mile below Clarendon Mills, West Boylston.  
Not wooded or cultivated. Samples taken from Surface to Three Feet below  
Surface. All Samples dried at 100°C.*

|                                           | Loss<br>on Ignition.<br>(Per Cent.) | Carbon.<br>(Per Cent.) | Nitrogen.<br>(Per Cent.) | Ratio.<br>$\frac{c}{n}$ |
|-------------------------------------------|-------------------------------------|------------------------|--------------------------|-------------------------|
| 2a. Surface to 2 in. below, . . . .       | 4.55                                | 2.26                   | 0.14                     | 16.1                    |
| 2b. 2 in. to 4 in. below surface, . . .   | 10.19                               | 5.00                   | 0.27                     | 18.5                    |
| 2c. 4 in. to 7 in. below surface, . . .   | 7.62                                | 2.62                   | 0.36                     | 7.0                     |
| 2d. 7 in. to 10 in. below surface, . . .  | 7.70                                | 2.93                   | 0.21                     | 14.0                    |
| 2e. 10 in. to 16 in. below surface, . . . | 1.01                                | 0.13                   | 0.05                     | 3.6                     |
| 2f. 16 in. to 22 in. below surface, . . . | 1.63                                | 0.24                   | 0.13                     | 1.8                     |
| 2g. 3 feet below surface, . . . .         | 0.80                                | 0.23                   | 0.08                     | 7.7                     |

*Sanitary Analysis of Water with which the Soils had been treated as described.*

[Parts per 100,000.]

|                                         | Free<br>Ammonia. | Free<br>Ammonia<br>after<br>Standing<br>One Week. | Albuminoid<br>Ammonia. | Oxygen<br>Consumed. | Color with<br>Distilled<br>Water. | Effect<br>of Soils on<br>Color of<br>Cochituate<br>Water of<br>Color 0.55. |
|-----------------------------------------|------------------|---------------------------------------------------|------------------------|---------------------|-----------------------------------|----------------------------------------------------------------------------|
| 2a. Surface to 2 in. below, . . .       | 0.0340           | 0.0669                                            | 0.0852                 | 1.4732              | 0.40                              | 0.90                                                                       |
| 2b. 2 in. to 4 in. below surface, . .   | 0.0227           | 0.1216                                            | 0.1372                 | 2.3334              | 0.48                              | 1.00                                                                       |
| 2c. 4 in. to 7 in. below surface, . .   | 0.0227           | 0.0335                                            | 0.1261                 | 2.3092              | 0.35                              | 0.85                                                                       |
| 2d. 7 in. to 10 in. below surface, . .  | 0.0178           | 0.0062                                            | 0.1349                 | 2.0945              | 0.52                              | 0.85                                                                       |
| 2e. 10 in. to 16 in. below surface, . . | 0.0307           | 0.0130                                            | 0.0205                 | 0.5428              | 0.15                              | 0.70                                                                       |
| 2f. 16 in. to 22 in. below surface, . . | 0.0190           | 0.0000                                            | 0.0196                 | 0.4560              | -                                 | -                                                                          |
| 2g. 3 feet below surface, . . .         | 0.0323           | 0.0213                                            | 0.0267                 | 0.3756              | 0.00                              | 0.45                                                                       |

## SERIES 3.

*From Pasture Land One Mile North of South Clinton Station. Sandy and Gravelly and Nearly Level. Samples taken from Surface to Three Feet below Surface. All Samples dried at 100°C.*

|                                           | Loss<br>on Ignition.<br>(Per Cent.) | Carbon.<br>(Per Cent.) | Nitrogen.<br>(Per Cent.) | Ratio.<br>$\frac{c}{n}$ |
|-------------------------------------------|-------------------------------------|------------------------|--------------------------|-------------------------|
| 3a. Surface to 2 in. below, . . . .       | 7.85                                | 3.51                   | 0.27                     | 13.0                    |
| 3b. 2 in. to 4 in. below surface, . . .   | 5.85                                | 2.18                   | 0.24                     | 9.1                     |
| 3c. 4 in. to 6 in. below surface, . . .   | 4.93                                | 2.28                   | 0.20                     | 11.4                    |
| 3d. 6 in. to 11 in. below surface, . . .  | 1.73                                | 0.50                   | 0.03                     | 16.7                    |
| 3e. 11 in. to 16 in. below surface, . . . | 1.43                                | 0.13                   | 0.04                     | 3.3                     |
| 3f. 16 in. to 36 in. below surface, . . . | 0.81                                | 0.02                   | 0.02                     | 1.0                     |

*Sanitary Analysis of Water with which the Soils had been treated as described.*

[Parts per 100,000.]

|                                         | Free<br>Ammonia. | Free<br>Ammonia<br>after<br>Standing<br>One Week. | Albuminoid<br>Ammonia. | Oxygen<br>Consumed. | Color with<br>Distilled<br>Water. | Effect<br>of Soils on<br>Color of<br>Cochineate<br>Water of<br>Color 0.55. |
|-----------------------------------------|------------------|---------------------------------------------------|------------------------|---------------------|-----------------------------------|----------------------------------------------------------------------------|
| 3a. Surface to 2 in. below, . . .       | 0.0341           | 0.0541                                            | 0.1540                 | 1.4423              | 0.30                              | 0.60                                                                       |
| 3b. 2 in. to 4 in. below surface, . .   | 0.0457           | 0.0693                                            | 0.1041                 | 1.4855              | 0.22                              | 0.65                                                                       |
| 3c. 4 in. to 6 in. below surface, . .   | 0.0857           | 0.0745                                            | 0.0888                 | 1.2000              | 0.15                              | 0.60                                                                       |
| 3d. 6 in. to 11 in. below surface, . .  | 0.0427           | 0.0138                                            | 0.0321                 | 0.4361              | 0.12                              | 0.50                                                                       |
| 3e. 11 in. to 16 in. below surface, . . | 0.0400           | 0.0290                                            | 0.0125                 | 0.1689              | 0.00                              | 0.18                                                                       |
| 3f. 16 in. to 36 in. below surface, . . | 0.0214           | 0.0121                                            | 0.0067                 | 0.1000              | 0.00                              | 0.33                                                                       |



## SERIES 4.

*From a very Steep, Clayey Hillside near Site of Proposed Dam. Samples taken from Surface to Three Feet below Surface. All Samples dried at 100°C.*

|                                           | Loss<br>on ignition.<br>(Per Cent.) | Carbon.<br>(Per Cent.) | Nitrogen.<br>(Per Cent.) | Ratio.<br>$\frac{c}{n}$ |
|-------------------------------------------|-------------------------------------|------------------------|--------------------------|-------------------------|
| 4a. Surface to 2 in. below, . . . .       | 17.79                               | 8.19                   | 0.56                     | 14.6                    |
| 4b. 2 in. to 4 in. below surface, . . .   | 11.04                               | 5.85                   | 0.38                     | 15.4                    |
| 4c. 4 in. to 6 in. below surface, . . .   | 8.56                                | 4.31                   | 0.12                     | 35.9                    |
| 4d. 6 in. to 11 in. below surface, . . .  | 4.04                                | 1.26                   | 0.05                     | 25.2                    |
| 4e. 11 in. to 16 in. below surface, . . . | 2.80                                | 0.47                   | 0.03                     | 15.7                    |
| 4f. 3 feet below surface, . . . .         | 1.76                                | 0.10                   | 0.01                     | 10.0                    |

*Sanitary Analysis of Water with which the Soils had been treated as described.*

[Parts per 100,000.]

|                                         | Free<br>Ammonia. | Free<br>Ammonia<br>after<br>Standing<br>One Week. | Albuminoid<br>Ammonia. | Oxygen<br>Consumed. | Color with<br>Distilled<br>Water. | Effect<br>of Soils on<br>Color of<br>Cochituate<br>Water of<br>Color 0.55. |
|-----------------------------------------|------------------|---------------------------------------------------|------------------------|---------------------|-----------------------------------|----------------------------------------------------------------------------|
| 4a. Surface to 2 in. below, . . .       | 0.0622           | 0.3555                                            | 0.4240                 | 7.7333              | 0.30                              | 0.75                                                                       |
| 4b. 2 in. to 4 in. below surface, . .   | 0.2581           | 0.4749                                            | 0.8032                 | 8.0323              | 0.30                              | 0.75                                                                       |
| 4c. 4 in. to 6 in. below surface, . .   | 0.0454           | 0.1513                                            | 0.1968                 | 4.2622              | 0.48                              | 0.80                                                                       |
| 4d. 6 in. to 11 in. below surface, . .  | 0.0071           | 0.0267                                            | 0.0542                 | 1.0422              | 0.32                              | 0.55                                                                       |
| 4e. 11 in. to 16 in. below surface, . . | 0.0077           | 0.0154                                            | 0.0369                 | 0.5427              | 0.12                              | 0.55                                                                       |
| 4f. 3 feet below surface, . . .         | 0.0138           | 0.0092                                            | 0.0155                 | 0.3000              | 0.40                              | 0.70                                                                       |

## SERIES 5.

*From Level Pasture Land near River, Half a Mile East of Boylston Station. Silt Formation. Samples taken from Surface to Three Feet Six Inches below Surface. All Samples dried at 100° C.*

|                                           | Loss<br>on Ignition.<br>(Per Cent.) | Carbon.<br>(Per Cent.) | Nitrogen.<br>(Per Cent.) | Ratio.<br>$\frac{c}{n}$ |
|-------------------------------------------|-------------------------------------|------------------------|--------------------------|-------------------------|
| 5a. Surface to 2 in. below, . . . .       | 9.40                                | 4.19                   | 0.43                     | 9.7                     |
| 5b. 2 in. to 4 in. below surface, . . .   | 3.94                                | 1.33                   | 0.15                     | 8.9                     |
| 5c. 4 in. to 7 in. below surface, . . .   | 3.04                                | 1.02                   | 0.11                     | 9.3                     |
| 5d. 7 in. to 10 in. below surface, . . .  | 2.12                                | 0.63                   | 0.10                     | 6.3                     |
| 5e. 10 in. to 15 in. below surface, . . . | 2.51                                | 0.73                   | 0.09                     | 8.1                     |
| 5f. 15 in. to 20 in. below surface, . . . | 0.88                                | 0.16                   | 0.03                     | 5.3                     |
| 5g. 3 ft. 6 in. below surface, . . . .    | 1.09                                | 0.21                   | 0.02                     | 10.5                    |

*Sanitary Analysis of Water with which the Soils had been treated as described.*

[Parts per 100,000.]

|                                         | Free<br>Ammonia. | Free<br>Ammonia<br>after<br>Standing<br>One Week. | Albuminoid<br>Ammonia. | Oxygen<br>Consumed. | Color with<br>Distilled<br>Water. | Effect<br>of Soils on<br>Color of<br>Cochineate<br>Water of<br>Color 6.55. |
|-----------------------------------------|------------------|---------------------------------------------------|------------------------|---------------------|-----------------------------------|----------------------------------------------------------------------------|
| 5a. Surface to 2 in. below, . . .       | 0.0349           | 0.2573                                            | 0.5556                 | 2.7619              | 0.20                              | 0.70                                                                       |
| 5b. 2 in. to 4 in. below surface, . .   | 0.0533           | 0.0195                                            | 0.0636                 | 1.5876              | 0.20                              | 0.65                                                                       |
| 5c. 4 in. to 7 in. below surface, . .   | 0.0380           | 0.0099                                            | 0.0670                 | 0.8444              | 0.20                              | 0.70                                                                       |
| 5d. 7 in. to 10 in. below surface, . .  | 0.0166           | 0.0325                                            | 0.0316                 | 0.2382              | 0.20                              | 0.60                                                                       |
| 5e. 10 in. to 15 in. below surface, . . | 0.0182           | 0.0117                                            | 0.0519                 | 0.6127              | 0.25                              | 0.70                                                                       |
| 5f. 15 in. to 20 in. below surface, . . | 0.0183           | 0.0041                                            | 0.0199                 | 0.2726              | 0.00                              | 0.45                                                                       |
| 5g. 3 ft. 6 in. below surface, . . .    | 0.0295           | 0.0533                                            | 0.0116                 | 0.2036              | 0.05                              | 0.50                                                                       |

## SERIES 6.

*From Three-quarters of a Mile West of Boylston Centre on Wooded Hillside East of Muddy Brook. Samples taken from Surface to Three Feet below Surface. All Samples dried at 100° C.*

|                                           | Loss<br>on Ignition.<br>(Per Cent.) | Carbon.<br>(Per Cent.) | Nitrogen.<br>(Per Cent.) | Ratio.<br>$\frac{c}{n}$ |
|-------------------------------------------|-------------------------------------|------------------------|--------------------------|-------------------------|
| 6a. Surface to 2 in. below, . . . .       | 9.69                                | 8.93                   | 0.11                     | 81.2                    |
| 6b. 2 in. to 4 in. below surface, . . .   | 4.31                                | 1.80                   | 0.04                     | 32.5                    |
| 6c. 4 in. to 7 in. below surface, . . .   | 4.06                                | 0.91                   | 0.11                     | 8.3                     |
| 6d. 7 in. to 10 in. below surface, . . .  | 2.83                                | 0.69                   | 0.02                     | 34.5                    |
| 6e. 10 in. to 16 in. below surface, . . . | 2.50                                | 0.30                   | 0.02                     | 15.0                    |
| 6f. 3 ft. below surface, . . . . .        | 1.77                                | 0.16                   | 0.01                     | 16.0                    |

*Sanitary Analysis of Water with which the Soils had been treated as described.*

[Parts per 100,000.]

|                                         | Free<br>Ammonia. | Free<br>Ammonia<br>after<br>Standing<br>One Week. | Albuminoid<br>Ammonia. | Oxygen<br>Consumed. | Color with<br>Distilled<br>Water. | Effect<br>of Soils on<br>Color of<br>Cochineate<br>Water of<br>Color 0.55. |
|-----------------------------------------|------------------|---------------------------------------------------|------------------------|---------------------|-----------------------------------|----------------------------------------------------------------------------|
| 6a. Surface to 2 in. below, . . .       | 0.0800           | 0.2921                                            | 0.4726                 | 7.0009              | 0.60                              | 1.00                                                                       |
| 6b. 2 in. to 4 in. below surface, . .   | 0.0392           | 0.0574                                            | 0.0770                 | 1.5740              | 0.30                              | 0.70                                                                       |
| 6c. 4 in. to 7 in. below surface, . .   | 0.0361           | 0.0323                                            | 0.0619                 | 1.0977              | 0.38                              | 0.60                                                                       |
| 6d. 7 in. to 10 in. below surface, . .  | 0.0209           | 0.0116                                            | 0.0243                 | 0.3368              | 0.10                              | 0.53                                                                       |
| 6e. 10 in. to 16 in. below surface, . . | 0.0340           | 0.0142                                            | 0.0288                 | 0.5060              | 0.20                              | 0.55                                                                       |
| 6f. 3 ft. below surface, . . . . .      | 0.0142           | 0.0077                                            | 0.0110                 | 0.1478              | 0.00                              | 0.10                                                                       |

## SERIES 7.

*From Swamp at Head of Boylston Millpond, about Three-quarters of a Mile above Boylston Station. Samples taken from Surface to Three Feet Three Inches below Surface. All Samples dried at 100° C.*

|                                             | Loss<br>on Ignition.<br>(Per Cent.) | Carbon.<br>(Per Cent.) | Nitrogen.<br>(Per Cent.) | Ratio.<br>$\frac{c}{n}$ |
|---------------------------------------------|-------------------------------------|------------------------|--------------------------|-------------------------|
| 7a. Surface to 2 in. below, . . . .         | 22.31                               | 12.53                  | 0.96                     | 13.0                    |
| 7b. 2 in. to 4 in. below surface, . . . .   | 24.59                               | 13.05                  | 0.54                     | 24.2                    |
| 7c. 4 in. to 8 in. below surface, . . . .   | 17.12                               | 8.75                   | 0.86                     | 10.2                    |
| 7d. 8 in. to 12 in. below surface, . . . .  | 9.14                                | 3.96                   | 0.21                     | 18.9                    |
| 7e. 12 in. to 21 in. below surface, . . . . | 3.93                                | 1.44                   | 0.09                     | 16.0                    |
| 7f. 21 in. to 39 in. below surface, . . . . | 1.93                                | 0.51                   | 0.04                     | 12.3                    |
| 7g. 39 in. below surface, . . . .           | 0.66                                | 0.06                   | 0.00                     | 0.0                     |

*Sanitary Analysis of Water with which the Soils had been treated as described.*

[Parts per 100,000.]

|                                             | Free<br>Ammonia. | Free<br>Ammonia<br>after<br>Standing<br>One Week. | Albuminoid<br>Ammonia. | Oxygen<br>Consumed. | Color with<br>Distilled<br>Water. | Effect<br>of Soils on<br>Color of<br>Cochineate<br>Water of<br>Color 0.55. |
|---------------------------------------------|------------------|---------------------------------------------------|------------------------|---------------------|-----------------------------------|----------------------------------------------------------------------------|
| 7a. Surface to 2 in. below, . . . .         | 0.1360           | 0.4000                                            | 0.4970                 | 6.4000              | 0.40                              | 0.70                                                                       |
| 7b. 2 in. to 4 in. below surface, . . . .   | 0.1486           | 0.5429                                            | 0.4486                 | 7.4286              | 0.50                              | 0.90                                                                       |
| 7c. 4 in. to 8 in. below surface, . . . .   | 0.1360           | 0.3440                                            | 0.4970                 | 4.6000              | 0.12                              | 0.55                                                                       |
| 7d. 8 in. to 12 in. below surface, . . . .  | 0.0274           | 0.0709                                            | 0.0937                 | 2.7429              | 0.50                              | 1.00                                                                       |
| 7e. 12 in. to 21 in. below surface, . . . . | 0.0305           | 0.0267                                            | 0.0438                 | 1.0857              | 0.30                              | 0.70                                                                       |
| 7f. 21 in. to 39 in. below surface, . . . . | 0.0173           | 0.0220                                            | 0.0602                 | 0.8471              | 0.10                              | 0.55                                                                       |
| 7g. 39 in. below surface, . . . .           | 0.0179           | 0.0245                                            | 0.0080                 | 0.1365              | 0.02                              | 0.45                                                                       |

## SERIES 8.

*From Bottom of Oakdale Millpond from Depths of Three to Twelve Feet. All Samples dried at 100°C.*

|                                                                | Loss<br>on Ignition.<br>(Per Cent.) | Carbon.<br>(Per Cent.) | Nitrogen.<br>(Per Cent.) | Ratio<br>$\frac{c}{n}$ |
|----------------------------------------------------------------|-------------------------------------|------------------------|--------------------------|------------------------|
| 8a. Near head in 3 ft. of water, . . . . .                     | 0.91                                | 0.07                   | 0.01                     | 7.0                    |
| 8b. $\frac{1}{2}$ mile below head in 5 ft. of water, . . . . . | 0.11                                | 0.06                   | 0.00                     | 0.0                    |
| 8c. $\frac{1}{2}$ mile below head in 7 ft. of water, . . . . . | 10.16                               | 4.10                   | 0.36                     | 11.4                   |
| 8d. $\frac{1}{2}$ mile from head in 9 ft. of water, . . . . .  | 10.45                               | 4.17                   | 0.35                     | 11.9                   |
| 8e. 500 ft. above W. & N. R.R. in 12 ft. of water, . . .       | 14.75                               | 6.56                   | 0.53                     | 12.4                   |
| 8f. 500 ft. below W. & N. R.R. in 12 ft. of water, . . .       | 4.72                                | 2.18                   | 0.15                     | 14.5                   |

*Sanitary Analysis of Water with which the Soils had been treated as described.*

[Parts per 100,000.]

|                                                         | Free<br>Ammonia. | Free<br>Ammonia<br>after<br>Standing<br>One Week. | Albuminoid<br>Ammonia. | Oxygen<br>Consumed. | Color with<br>Distilled<br>Water. | Effect<br>of Soils on<br>Color of<br>Cochineate<br>Water of<br>Color 0.55. |
|---------------------------------------------------------|------------------|---------------------------------------------------|------------------------|---------------------|-----------------------------------|----------------------------------------------------------------------------|
| 8a. Near head in 3 ft. of water, .                      | 0.0186           | 0.0121                                            | 0.0251                 | 0.2224              | 0.01                              | 0.55                                                                       |
| 8b. $\frac{1}{2}$ mile below head in 5 ft. of<br>water. | 0.0162           | 0.0027                                            | 0.0144                 | 0.1854              | 0.00                              | 0.60                                                                       |
| 8c. $\frac{1}{2}$ mile below head in 7 ft. of<br>water. | 0.2100           | 0.2000                                            | 0.2042                 | 3.1408              | 0.50                              | 0.90                                                                       |
| 8d. $\frac{1}{2}$ mile from head in 9 ft. of<br>water.  | 0.1707           | 0.2240                                            | 0.2227                 | 3.8500              | 0.50                              | 0.70                                                                       |
| 8e. 500 ft. above W. & N. R.R. in<br>12 ft. of water.   | 0.1043           | 0.2236                                            | 0.1838                 | 2.7500              | 0.30                              | 0.75                                                                       |
| 8f. 500 ft. below W. & N. R.R. in<br>12 ft. of water.   | 0.1103           | 0.0855                                            | 0.0790                 | 1.3707              | 0.55                              | 0.85                                                                       |

## SERIES 9.

*From Pasture Land about One and One-quarter Miles below West Boylston, on South Side of Railroad, which had never been cultivated. Samples taken from Surface to Twenty Inches below Surface. Samples dried at 100°C.*

|                                   | Moisture.<br>(Per Cent.) | Loss on<br>Ignition.<br>(Per Cent.) | Hydrogen.<br>(Per Cent.) | Carbon.<br>(Per Cent.) | Nitrogen.<br>(Per Cent.) | Ratio.<br>$\frac{c}{n}$ |
|-----------------------------------|--------------------------|-------------------------------------|--------------------------|------------------------|--------------------------|-------------------------|
| 9a. Surface to 2 in. below, . . . | 31.13                    | 19.89                               | 1.45                     | 11.92                  | 0.66                     | 18.06                   |
| 9b. 2 in. to 4 in. below, . . .   | 29.17                    | 11.52                               | 0.66                     | 5.32                   | 0.48                     | 11.08                   |
| 9c. 4 in. to 7 in. below, . . .   | 26.17                    | 8.37                                | 0.62                     | 3.56                   | 0.26                     | 13.69                   |
| 9d. 7 in. to 10 in. below, . . .  | 26.19                    | 5.16                                | 0.42                     | 1.38                   | 0.03                     | 46.00                   |
| 9e. 10 in. to 15 in. below, . . . | 22.55                    | 3.16                                | 0.31                     | 0.87                   | 0.06                     | 14.50                   |
| 9f. 15 in. to 20 in. below, . . . | 18.47                    | 2.43                                | 0.22                     | 0.85                   | 0.08                     | 10.63                   |

*Sanitary Analysis of Water with which the Soils had been treated as described.*

[Parts per 100,000.]

|           | FREE AMMONIA.       |                     | ALBUMINOID AM-<br>MONIA. |                     | OXYGEN CONSUMED.    |                     | COLOR.              |                     |
|-----------|---------------------|---------------------|--------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|           | After<br>3<br>Days. | After<br>1<br>Week. | After<br>3<br>Days.      | After<br>1<br>Week. | After<br>3<br>Days. | After<br>1<br>Week. | After<br>3<br>Days. | After<br>1<br>Week. |
| 9a, . . . | 0.0096              | 0.0024              | 0.0530                   | 0.1436              | 1.8330              | 2.1840              | 1.15                | 1.50                |
| 9b, . . . | 0.0056              | 0.0008              | 0.0254                   | 0.0228              | 0.3003              | 0.4368              | 0.15                | 0.25                |
| 9c, . . . | 0.0040              | 0.0072              | 0.0188                   | 0.0180              | 0.1170              | 0.1326              | 0.04                | 0.10                |
| 9d, . . . | 0.0016              | 0.0048              | 0.0066                   | 0.0078              | 0.0429              | 0.0702              | 0.00                | 0.00                |
| 9e, . . . | 0.0006              | 0.0104              | 0.0066                   | 0.0072              | 0.0156              | 0.0585              | 0.00                | 0.00                |
| 9f, . . . | 0.0048              | 0.0016              | 0.0050                   | 0.0052              | 0.0195              | 0.0624              | 0.00                | 0.00                |

## SERIES 10.

*From Land recently cleared of Good-sized Timber and never cultivated, about Midway between Boylston and South Clinton, South Side of Valley. Samples taken from Surface to Two Feet Six Inches below. Dried at 100°C.*

|                                    | Moisture.<br>(PerCent.) | Loss on<br>Ignition.<br>(PerCent.) | Hydrogen.<br>(Per Cent.) | Carbon.<br>(PerCent.) | Nitrogen.<br>(PerCent.) | Ratio.<br>$\frac{c}{n}$ |
|------------------------------------|-------------------------|------------------------------------|--------------------------|-----------------------|-------------------------|-------------------------|
| 10a. Surface to 2 in. below, . . . | 62.87                   | 26.65                              | 1.92                     | 18.07                 | 0.94                    | 19.22                   |
| 10b. 2 in. to 4 in. below, . . .   | 54.26                   | 19.63                              | 1.15                     | 10.47                 | 0.58                    | 18.02                   |
| 10c. 4 in. to 7 in. below, . . .   | 44.23                   | 11.12                              | 0.63                     | 5.66                  | 0.32                    | 17.69                   |
| 10d. 7 in. to 12 in. below, . . .  | 32.21                   | 3.40                               | 0.34                     | 1.54                  | 0.20                    | 7.70                    |
| 10e. 12 in. to 17 in. below, . . . | 29.57                   | 2.85                               | 0.28                     | 0.85                  | 0.31                    | 2.74                    |
| 10f. 2 ft. 6 in. below, . . .      | 17.60                   | 0.52                               | 0.05                     | 0.04                  | 0.11                    | 0.36                    |

*Sanitary Analysis of Water with which the Soils had been treated as described.*

[Parts per 100,000.]

|            | FREE AMMONIA.       |                     | ALBUMINOID AM-<br>MONIA. |                     | OXYGEN CONSUMED.    |                     | COLOR.              |                     |
|------------|---------------------|---------------------|--------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|            | After<br>3<br>Days. | After<br>1<br>Week. | After<br>3<br>Days.      | After<br>1<br>Week. | After<br>3<br>Days. | After<br>1<br>Week. | After<br>3<br>Days. | After<br>1<br>Week. |
| 10a, . . . | 0.0560              | 0.0384              | 0.0902                   | 0.1420              | 4.0560              | 6.3180              | -                   | 7.50                |
| 10b, . . . | 0.0232              | 0.0224              | 0.0382                   | 0.0320              | 0.8970              | 1.0257              | 0.80                | 4.50                |
| 10c, . . . | 0.0064              | 0.0032              | 0.0264                   | 0.0208              | 0.5144              | 0.6512              | 0.80                | 1.00                |
| 10d, . . . | 0.0056              | 0.0024              | 0.0240                   | 0.0254              | 0.2440              | 0.6448              | 0.30                | 1.20                |
| 10e, . . . | 0.0056              | 0.0072              | 0.0738                   | 0.0436              | 0.1584              | 1.3280              | 0.08                | 1.00                |
| 10f, . . . | 0.0096              | 0.0024              | 0.0074                   | 0.0066              | 0.0864              | 0.1008              | 0.03                | 0.12                |

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**EXPERIMENTS**  
**UPON THE**  
**PURIFICATION OF SEWAGE AND WATER**  
**AT THE**  
**LAWRENCE EXPERIMENT STATION,**  
**DURING THE YEAR 1893.**

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## EXPERIMENTS UPON THE PURIFICATION OF SEWAGE AND WATER AT THE LAWRENCE EXPERIMENT STATION.\*

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By GEORGE W. FULLER, Biologist in Charge.

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The year 1893 is the sixth that the experimental work of the Lawrence Experiment Station has been continued. The work is carried on under the general supervision of Hiram F. Mills, A.M., C.E., a member of the State Board of Health. Mr. Allen Hazen, chemist, was in direct charge of the station until March 1, 1893, when he was given a leave of absence and accepted the position of chemist to the Department of Water Supply and Sewerage of the World's Columbian Exposition. The writer, who had previously been in charge of the biological department, succeeded Mr. Hazen in charge of the station. Mr. Harry W. Clark is chemist, and Mr. F. L. Fales has compiled the records and prepared the tables showing the results of the work. Messrs. W. R. Copeland and Louis Weinberg are assistant biologists and Mr. F. B. Forbes is assistant chemist. Professors T. M. Drown and W. T. Sedgwick of the Massachusetts Institute of Technology are, respectively, consulting chemist and biologist, having a general oversight of the chemical and biological investigations.

The year has been an important one in the history of the experimental sewage filters, in that the results of earlier investigations have been confirmed and additional knowledge has been obtained as to the management necessary to maintain the continuous efficiency of such filters.

The process of purification of sewage by intermittent filtration consists of intermingling the sewage in the pores of the filtering material with sufficient air, for a sufficient time, in the presence of micro-organisms which quickly establish themselves there.

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\* A full account of the work done at the Lawrence Experiment Station for the years 1888 and 1889 is contained in a Special Report of the State Board of Health upon the Purification of Sewage and Water, 1890. A similar account for the years 1890 and 1891 is contained in the Twenty-third Annual Report of the Board for the year 1891, and for the year 1892 in the Twenty-fourth Annual Report of the Board for that year.

Sewage filters resemble complex living organisms, in that ventilation and respiration must be maintained, otherwise their functions are interrupted and their lives as filters come to an end.

When sewage passes through a filter a portion of the insoluble matter or sludge is deposited upon or near the surface. The result, eventually, unless preventive measures are adopted, is a clogging at the surface, which, owing to interrupted ventilation, causes a deterioration in the quality of the effluent, and subsequently, owing to the increased capillary attraction and frictional resistance to the passage of sewage, a reduction in the quantitative efficiency of the filter. The amount of sludge in sewage varies, but, unless care is taken, any sewage will in time clog any ordinary filter. In the Annual Report of the Board for 1892 it was stated that when other conditions are the same, the clogging is proportional to the sludge carried in the applied sewage. It is of importance therefore to consider not only the filtering materials but also the applied sewage in order to learn its average strength and the limits in strength between which it varies.

#### CHARACTER OF THE SEWAGE.

The sewage used at the Experiment Station is pumped through a two and one-half inch pipe, 4,300 feet long, from a sewer which drains the streets, houses and stores of the most densely populated sections of the city of Lawrence.

#### *Samples of Sewage for Analysis.*

Samples of sewage have been regularly collected for analysis as follows : —

1. *Regular Sewage.* On at least four days in a week a gallon bottle has been filled from a large tank of sewage. While the sample was intended to be as far as possible a representative one, it necessarily represented accurately only a small fraction of the total amount of sewage used ; and there is also considerable difficulty in mixing several hundred gallons of sewage so as to get a sample with its proper share of suspended matter.

2. *Average Sewage.* On one day each week (Tuesday), a sample has been taken by collecting directly from the pump (without allowing any opportunity for sedimentation), quantities of sewage propor-

tional to the amount of each lot of sewage pumped during the day. The average results from numerous samples collected in this manner give satisfactorily the average composition of all sewage applied to the filters.

3. *Sewage for Filters Nos. 1, 6 and 9A.* In order to learn the variations in strength of sewage at different times of the day and to obtain more accurate data upon the storage of organic matter in the filters there have been collected weekly three mixed samples representing each dose applied during the week to Filters Nos. 1, 6 and 9A, respectively. In order to keep the samples for one week without putrefaction and decomposition, a small amount of mercuric acetate was placed in the bottle.

*Monthly Averages of Analyses of Regular Sewage Samples.*

[Parts per 100,000.]

| MONTH—1893.          | Free Ammonia. | ALBUMINOID AMMONIA. |          |            | Chlorine. | Oxygen Consumed.* | Fats. | Bacteria per Cubic Centimeter. |
|----------------------|---------------|---------------------|----------|------------|-----------|-------------------|-------|--------------------------------|
|                      |               | Total.              | Soluble. | Insoluble. |           |                   |       |                                |
| January, . . . . .   | 2.44          | .68                 | .41      | .42        | 8.22      | 4.98              | 3.9   | 1,104,000                      |
| February, . . . . .  | 2.41          | .68                 | .37      | .31        | 6.93      | 4.33              | 2.4   | 985,000                        |
| March, . . . . .     | 2.02          | .64                 | .34      | .30        | 6.05      | 4.15              | 3.3   | 907,000                        |
| April, . . . . .     | 2.42          | .63                 | .35      | .48        | 6.57      | 4.16              | 1.7   | 1,109,000                      |
| May, . . . . .       | 2.23          | .51                 | .30      | .21        | 6.58      | 2.82              | 2.5   | 755,000                        |
| June, . . . . .      | 2.54          | .53                 | .28      | .25        | 11.37     | 2.63              | —     | 774,000                        |
| July, . . . . .      | 3.02          | .63                 | .32      | .31        | 8.71      | 2.72              | —     | 854,000                        |
| August, . . . . .    | 2.82          | .45                 | .22      | .23        | 10.66     | 2.53              | —     | 965,000                        |
| September, . . . . . | 2.75          | .47                 | .22      | .25        | 9.92      | 2.44              | —     | 686,000                        |
| October, . . . . .   | 3.07          | .61                 | .25      | .36        | 10.72     | 2.92              | —     | 1,125,000                      |
| November, . . . . .  | 3.28          | .71                 | .29      | .42        | 10.79     | 4.29              | —     | 1,000,000                      |
| December, . . . . .  | 3.16          | .70                 | .33      | .37        | 6.29      | 3.51              | —     | 861,000                        |
| Averages, . . . . .  | 2.68          | .63                 | .31      | .32        | 8.57      | 3.45              | —     | 923,000                        |

\* In all of the Lawrence analyses the oxygen consumed has been determined after boiling two minutes.

The above analyses represent four samples each week taken from one of the sewage tanks, usually in the morning, and the results are directly comparable with the analyses published for previous years.

*Monthly Averages of Analyses of Average Sewage Samples.*

[Parts per 100,000.]

| MONTH—1893.          | Free Ammonia. | ALBUMINOID AMMONIA. |          |            | Chlorine. | Oxygen Consumed. | Fats. |
|----------------------|---------------|---------------------|----------|------------|-----------|------------------|-------|
|                      |               | Total.              | Solable. | Insoluble. |           |                  |       |
| January, . . . . .   | 2.41          | .79                 | .37      | .42        | 6.69      | 4.46             | -     |
| February, . . . . .  | 2.36          | .75                 | .43      | .32        | 6.78      | 4.10             | -     |
| March, . . . . .     | 1.86          | .62                 | .58      | .24        | 4.33      | 3.50             | -     |
| April, . . . . .     | 2.39          | .70                 | .35      | .37        | 5.56      | 3.55             | -     |
| May, . . . . .       | 2.39          | .65                 | .30      | .35        | 6.28      | 2.90             | -     |
| June, . . . . .      | 2.86          | .63                 | .32      | .31        | 11.89     | 3.02             | -     |
| July, . . . . .      | 3.41          | .65                 | .29      | .36        | 9.05      | 2.95             | 4.1   |
| August, . . . . .    | 3.70          | .65                 | .28      | .37        | 7.88      | 3.27             | 3.0   |
| September, . . . . . | 3.80          | .70                 | .31      | .39        | 6.72      | 3.42             | 5.9   |
| October, . . . . .   | 3.77          | .85                 | .38      | .47        | 6.80      | 3.88             | 5.5   |
| November, . . . . .  | 4.06          | .95                 | .48      | .47        | 7.75      | 4.36             | 5.9   |
| December, . . . . .  | 3.85          | .93                 | .41      | .52        | 7.05      | 4.02             | 5.7   |
| Averages, . . . . .  | 3.07          | .74                 | .36      | .38        | 7.15      | 3.63             | -     |

The above analyses represent average samples of all the sewage pumped during the day for each Tuesday of the year.

*Monthly Averages of Mixed Samples, representing all of the Sewage applied to Filters Nos. 1, 6 and 9 A.*

[Parts per 100,000.]

| MONTH—1893.          | FREE AMMONIA. |               |                 | ALBUMINOID AMMONIA. |               |                 | OXYGEN CONSUMED. |               |                 | CHLORINE.     |               |                 | FATS.         |
|----------------------|---------------|---------------|-----------------|---------------------|---------------|-----------------|------------------|---------------|-----------------|---------------|---------------|-----------------|---------------|
|                      | Filter No. 1. | Filter No. 6. | Filter No. 9 A. | Filter No. 1.       | Filter No. 6. | Filter No. 9 A. | Filter No. 1.    | Filter No. 6. | Filter No. 9 A. | Filter No. 1. | Filter No. 6. | Filter No. 9 A. | Filter No. 1. |
| January, . . . . .   | 1.50          | 2.47          | 1.55            | .57                 | .76           | .52             | 3.40             | 4.45          | 3.80            | 4.48          | 7.79          | 4.77            | 4.6           |
| February, . . . . .  | 2.10          | 2.19          | 1.90            | .64                 | .81           | .59             | 3.40             | 4.92          | 3.67            | 9.41          | 5.94          | 6.04            | 2.0           |
| March, . . . . .     | 1.86          | 2.34          | 1.96            | .46                 | .61           | .48             | 4.00             | 4.50          | 4.00            | 5.72          | 5.91          | 7.14            | 3.3           |
| April, . . . . .     | 1.94          | 2.54          | 2.06            | .57                 | .73           | .63             | 2.82             | 3.72          | 3.02            | 6.02          | 5.58          | 5.67            | 2.4           |
| May, . . . . .       | 2.42          | 2.89          | 2.47            | .61                 | .43           | .62             | 2.73             | 3.07          | 3.06            | 6.14          | 6.26          | 5.97            | 4.6           |
| June, . . . . .      | 2.71          | 2.58          | 2.84            | .68                 | .64           | .61             | 3.02             | 3.70          | 3.20            | 8.17          | 7.45          | 9.70            | 3.4           |
| July, . . . . .      | 3.31          | 2.76          | 3.52            | .72                 | .73           | .88             | 3.22             | 3.52          | 3.82            | 9.98          | 12.50         | 8.83            | 3.7           |
| August, . . . . .    | 2.79          | 3.40          | 3.15            | .66                 | .67           | .51             | 3.39             | 3.97          | 2.87            | 10.03         | 9.13          | 9.54            | 5.9           |
| September, . . . . . | 3.56          | 3.91          | 3.55            | .77                 | .77           | .69             | 3.96             | 3.84          | 3.38            | 8.06          | 7.29          | 7.44            | 7.5           |
| October, . . . . .   | 3.79          | 4.29          | 4.26            | .82                 | .89           | .87             | 4.37             | 7.37          | 4.22            | 7.59          | 7.46          | 10.91           | 6.6           |
| November, . . . . .  | 3.97          | 3.84          | 4.26            | .88                 | .79           | 1.00            | 4.72             | 5.25          | 5.05            | 7.43          | 6.88          | 6.56            | 6.8           |
| December, . . . . .  | 3.04          | 3.75          | 3.22            | .82                 | .95           | .88             | 4.40             | 5.57          | 3.92            | 6.75          | 7.45          | 6.08            | 3.3           |
| Averages, . . . . .  | 2.75          | 3.04          | 2.88            | .68                 | .72           | .69             | 3.61             | 4.49          | 3.62            | 7.81          | 7.47          | 7.39            | 4.5           |

With regard to the comparison of the results with each other it is to be mentioned that the sewage for Filter No. 1 was all pumped late in the afternoon during the cold months, December to April, inclusive; in May and June it was pumped early in the morning, and during the rest of the year part in the early morning and the

remainder in the afternoon. Sewage for Filter No. 6 was regularly pumped in the middle of the day. In the case of Filter No. 9 A the sewage was pumped late in the afternoon during the cold months, December to April, inclusive, and early in the morning during the remainder of the year. The results are comparable with corresponding results obtained in 1892.

*Monthly Averages of Supernatant Liquid from Sewage settled with Alum for Filters Nos. 19 and 32.*

[Parts per 100,000.]

| MONTH—1893.          | Free Ammonia. | ALBUMINOID AMMONIA. |          |           | Chlorine. | Oxygen Consumed. | Fats. | Bacteria per Cubic Centimeter. |
|----------------------|---------------|---------------------|----------|-----------|-----------|------------------|-------|--------------------------------|
|                      |               | Total.              | Soluble. | Insoluble |           |                  |       |                                |
| January,* . . . . .  | 2.15          | .88                 | .27      | .11       | 5.40      | 2.70             | -     | 260,000                        |
| February, . . . . .  | 1.97          | .26                 | .19      | .07       | 6.56      | 2.72             | .2    | 77,500                         |
| March, . . . . .     | 1.91          | .28                 | .21      | .07       | 6.43      | 2.32             | .7    | 81,000                         |
| April, . . . . .     | 2.24          | .27                 | .22      | .05       | 5.57      | 1.83             | .5    | 20,000                         |
| May, . . . . .       | 2.29          | .28                 | .18      | .10       | 5.99      | 1.52             | 1.3   | 63,000                         |
| June, . . . . .      | 2.84          | .82                 | .20      | .12       | 9.86      | 1.62             | -     | 460,000                        |
| July, . . . . .      | 3.27          | .34                 | .23      | .11       | 7.66      | 1.60             | 1.5   | 230,000                        |
| August, . . . . .    | 2.48          | .24                 | .17      | .07       | 7.73      | 1.36             | .8    | 50,000                         |
| September, . . . . . | 2.80          | .27                 | .20      | .07       | 11.73     | 1.50             | 1.1   | 68,000                         |
| October, . . . . .   | 2.64          | .27                 | .18      | .09       | 5.98      | 1.47             | 3.3   | 315,000                        |
| November, . . . . .  | 3.04          | .82                 | .24      | .08       | 18.72     | 2.06             | 1.7   | 37,000                         |
| December, . . . . .  | 3.29          | .84                 | .24      | .10       | 5.74      | 1.92             | .9    | 187,000                        |
| Averages, . . . . .  | 2.54          | .30                 | .21      | .09       | 8.10      | 1.88             | 1.2   | 145,000                        |

\* The sewage was not treated in this manner January 1 to 20; the results for this month given in the table represent the analyses of January 21 to 31.

The above analyses represent the supernatant liquid after the sewage represented by the regular samples had been treated with alum, in the proportion of 1,000 pounds of alum to 1,000,000 gallons of sewage, and allowed to settle for four hours. These results show that 52.4 per cent. of the total albuminoid ammonia and 84.3 per cent. of the bacteria were removed. The high numbers of bacteria in June and July appeared to be due to a growth of bacteria on the sides of the barrels where some organic matter had accumulated. The removal of this organic matter from time to time caused the number of bacteria in the supernatant liquid to become normal.

*Monthly Averages of Supernatant Liquid from Settled Sewage for Filter No. 13 A.*

[Parts per 100,000.]

| MONTH — 1893.       | Free Ammonia. | ALBUMINOID AMMONIA. |          |            | Chlorine. | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|---------------------|---------------|---------------------|----------|------------|-----------|------------------|--------------------------------|
|                     |               | Total.              | Soluble. | Insoluble. |           |                  |                                |
| October, . . . . .  | 2.70          | .43                 | .25      | .18        | 6.22      | 2.32             | 844,000                        |
| November, . . . . . | 3.13          | .60                 | .32      | .28        | 18.73     | 3.64             | 898,000                        |
| December, . . . . . | 3.25          | .60                 | .30      | .30        | 5.98      | 3.12             | 856,000                        |
| Averages, . . . . . | 3.08          | .64                 | .29      | .25        | 10.31     | 2.99             | 866,000                        |

The analyses above represent the supernatant liquid after the sewage represented by the regular sample had been allowed to settle for four hours. These results, when compared with those of the regular samples of sewage, taken on the same days, show a removal of 18.2 per cent. of the total albuminoid ammonia and 12 0 per cent. of the bacteria by sedimentation.

*Comparison of the Strength of the Sewage.*

Bringing together for comparison the average results of the several series of sewage samples, we have : —

[Parts per 100,000.]

|                              | Free Ammonia. | ALBUMINOID AMMONIA. |          |            | Chlorine. | Oxygen Consumed. |
|------------------------------|---------------|---------------------|----------|------------|-----------|------------------|
|                              |               | Total.              | Soluble. | Insoluble. |           |                  |
| Regular, . . . . .           | 2.68          | .63                 | .31      | .32        | 8.57      | 3.45             |
| Average, . . . . .           | 3.07          | .74                 | .36      | .38        | 7.16      | 3.63             |
| For Filter No. 1, . . . . .  | 2.75          | .68                 | .31*     | .37        | 7.81      | 3.61             |
| For Filter No. 6, . . . . .  | 3.04          | .72                 | .31*     | .41        | 7.47      | 4.49             |
| For Filter No. 9A, . . . . . | 2.88          | .69                 | .31*     | .38        | 7.39      | 3.62             |

\* Estimated as equal to that in the regular sample.

It will be seen that the average sewage for the day was the most concentrated, although only a little stronger than the sewage applied to Filters Nos. 1, 6 and 9A. The regular sewage was the most dilute of all, as was the case in 1892.

Investigations are under way to show the relation of the strength of the sewage as drawn at the Experiment Station to that of the original sewage in the Lawrence Street sewer. The results of two such series of analyses are given in the table below. On January 16 and 17, 1894, when the first series was collected, the weather was

clear and cold, and probably very little surface water entered the sewer. The second series was taken during a storm. The amount of precipitation (rain and melted snow) was 1.47 inches, the greater part of which was snow; considerable rain fell during the night of January 30, however, and found its way to the sewer. In the second series estimates of the quantity of sewage flowing in the sewer were made from observations of the depth of sewage in the sewer.

*Results of Analyses of Hourly Samples of Sewage from the Lawrence Street Sewer.*

[Parts per 100,000.]

| January 16 and 17. |                            |          |        |            |           |                  |      |                            |        | January 20 and 21.                   |            |      |     |           |                  |       |                                   |  |  |
|--------------------|----------------------------|----------|--------|------------|-----------|------------------|------|----------------------------|--------|--------------------------------------|------------|------|-----|-----------|------------------|-------|-----------------------------------|--|--|
| HOUR.              | Temperature.<br>Degrees F. | AMMONIA. |        |            | Chlorine. | Oxygen Consumed. |      | TEMPERATURE.<br>DEGREES F. |        | Rate. Million Gals.<br>per 24 Hours. | AMMONIA.   |      |     | Chlorine. | Oxygen Consumed. | Fats. | Bacteria per Cubic<br>Centimeter. |  |  |
|                    |                            | Free.    | Total. | Insoluble. |           | Sewage.          | Air. | Free.                      | Total. |                                      | Insoluble. |      |     |           |                  |       |                                   |  |  |
| 6 P.M.             | 42.                        | 1.20     | .56    | .23        | 6.16      | 6.70             | .7   | -                          | 84.5   | 1.1                                  | 1.26       | .53  | .18 | 4.70      | 3.00             | 2.0   | 580,000                           |  |  |
| 7 "                | 42.5                       | 1.30     | .42    | .12        | 3.80      | 3.70             | 4.1  | 46.                        | 34.    | .9                                   | 1.45       | .56  | .16 | 5.17      | 3.10             | 2.3   | 413,000                           |  |  |
| 8 "                | 43.                        | 1.85     | .50    | .16        | 4.66      | 1.80             | 2.4  | 43.                        | 33.    | 1.3                                  | 1.70       | .53  | .27 | 4.29      | 2.60             | 2.8   | 543,000                           |  |  |
| 9 "                | 44.                        | 1.35     | .36    | .11        | 3.80      | 2.50             | 1.9  | 44.                        | 34.    | 1.3                                  | 1.40       | .37  | .09 | 3.78      | 2.20             | 1.6   | 615,000                           |  |  |
| 10 "               | 44.                        | 1.60     | .46    | .16        | 4.00      | 3.30             | 2.1  | 44.                        | 33.5   | 1.5                                  | 1.95       | .54  | .36 | 4.21      | 2.30             | 3.4   | 504,000                           |  |  |
| 11 "               | 43.                        | 1.15     | .26    | .07        | 3.30      | 1.80             | .8   | 43.                        | 34.    | .9                                   | 1.75       | .43  | .17 | 5.58      | 1.70             | 1.4   | 188,000                           |  |  |
| 12 "               | 44.                        | 1.05     | .22    | .04        | 2.80      | 1.50             | 1.3  | 42.5                       | 33.5   | .9                                   | 1.25       | .26  | .02 | 3.27      | 1.20             | 1.0   | 368,000                           |  |  |
| 1 A.M.             | 44.                        | .75      | .16    | .02        | 2.30      | 1.20             | 1.7  | 42.                        | 34.    | 1.1                                  | .80        | .18  | .04 | 2.32      | 1.10             | 2.1   | 441,000                           |  |  |
| 2 "                | 43.5                       | .60      | .17    | .04        | 2.10      | 1.00             | 1.4  | 41.                        | 34.5   | 1.6                                  | .45        | .15  | .02 | 21.09     | .90              | .4    | 234,000                           |  |  |
| 3 "                | 42.                        | .65      | .14    | .02        | 2.10      | .90              | 4.5  | 40.                        | 36.    | 1.8                                  | .55        | .13  | .01 | 3.77      | .90              | 1.2   | 164,000                           |  |  |
| 4 "                | 42.                        | .64      | .17    | .04        | 2.10      | .70              | 3.3  | 40.                        | 35.5   | 2.1                                  | .56        | .19  | .04 | 2.61      | .90              | 1.5   | 223,000                           |  |  |
| 5 "                | 42.5                       | .61      | .12    | .01        | 2.10      | .70              | 3.4  | 39.5                       | 33.5   | 2.4                                  | .63        | .14  | .02 | 3.30      | 1.00             | 2.0   | 133,000                           |  |  |
| 6 "                | 41.                        | .95      | .23    | .04        | 3.00      | 1.60             | 6.9  | 40.                        | 31.    | 1.8                                  | 1.04       | .28  | .07 | 4.08      | 1.20             | .4    | 470,000                           |  |  |
| 7 "                | 42.                        | 1.40     | .49    | .16        | 3.45      | 1.90             | 4.8  | 44.                        | 31.    | 1.8                                  | 1.35       | .40  | .12 | 3.58      | 2.40             | .5    | 546,000                           |  |  |
| 8 "                | 42.                        | 4.40     | .82    | .36        | 4.75      | 4.40             | 6.3  | 45.                        | 30.5   | 2.4                                  | 2.25       | 1.85 | .82 | 12.62     | 5.50             | 2.2   | 1,130,000                         |  |  |
| 9 "                | 47.                        | 4.55     | 1.14   | .64        | 5.50      | 5.50             | 4.3  | 46.                        | 31.    | 2.4                                  | 1.80       | .80  | .26 | 6.55      | 3.40             | 2.7   | 663,000                           |  |  |
| 10 "               | 48.                        | 4.10     | 1.49   | .93        | 6.30      | 6.40             | 11.0 | 46.                        | 30.    | 1.8                                  | 1.65       | .68  | .18 | 4.75      | 3.60             | 2.5   | 635,000                           |  |  |
| 11 "               | 48.5                       | 3.90     | 1.01   | .48        | 6.92      | 5.00             | 19.0 | 44.5                       | 30.5   | 2.1                                  | 1.35       | .54  | .11 | 4.18      | 5.40             | 3.4   | 412,000                           |  |  |
| 12 M.              | 48.                        | 4.30     | 1.19   | .67        | 6.32      | 5.00             | 16.9 | 46.                        | 32.5   | 2.6                                  | 1.96       | .54  | .14 | 4.83      | 3.30             | 3.9   | 549,000                           |  |  |
| 1 P.M.             | 46.                        | 2.55     | .73    | .20        | 6.52      | 5.00             | 11.2 | 45.                        | 29.5   | 2.4                                  | 1.75       | .56  | .21 | 4.31      | 3.40             | 2.6   | 406,000                           |  |  |
| 2 "                | 46.5                       | 3.25     | .98    | .38        | 8.32      | 5.50             | 16.6 | 45.                        | 29.5   | 2.4                                  | 1.90       | .70  | .26 | 8.20      | 5.50             | 3.9   | 580,000                           |  |  |
| 3 "                | 47.                        | 2.30     | .73    | .29        | 5.01      | 4.70             | 13.4 | 47.5                       | 28.    | 1.8                                  | 1.55       | .54  | .21 | 3.99      | 3.70             | 3.8   | 624,000                           |  |  |
| 4 "                | 47.5                       | 1.55     | .50    | .08        | 4.64      | 4.20             | 8.5  | 47.                        | 27.    | 2.1                                  | 1.30       | .58  | .16 | 3.48      | 3.30             | 1.2   | 365,000                           |  |  |
| 5 "                | -                          | 1.45     | .54    | .14        | 4.06      | 4.50             | 9.4  | -                          | -      | -                                    | -          | -    | -   | -         | -                | -     | -                                 |  |  |



From the data obtained in the second series there was calculated a representative analysis of all the sewage which passed through the sewer during this period of twenty-four hours. In the following table this representative analysis of all the sewage flowing for twenty-four hours in the sewer is compared with the average analysis of all the sewage pumped at the Experiment Station during this period (7 A.M. to 5 P.M. January 31).

[Parts per 100,000.]

| JANUARY 30 AND 31, 1894.     | Free Ammonia. | ALBUMINOID AMMONIA. |          |            | Chlorine. | Oxygen Consumed. |
|------------------------------|---------------|---------------------|----------|------------|-----------|------------------|
|                              |               | Total.              | Soluble. | Insoluble. |           |                  |
| Lawrence Street sewer, . . . | 1.40          | .54                 | .36      | .18        | 5.56      | 2.87             |
| Experiment station, . . .    | 2.70          | .73                 | .49      | .24        | 5.72      | 5.50             |

These results indicate that the average sewage applied to the experimental filters during this period was considerably stronger than the average original sewage flowing in the sewer. Whether or not the difference is always so marked will require further experiments to determine. It is instructive to compare the analyses of the sewage in the two series, and also the variations at different times during the day in each series.

It has been found that the sewage in the Lawrence Street sewer contains considerable dissolved oxygen, while the sewage as pumped at the Station contains none. Experiments are in progress to compare the results of purification by filtration of fresh sewage from the Lawrence Street sewer and of sewage as pumped at the Station, both with and without aeration.

Since clogging and consequent interference with ventilation are the chief factors to be considered in studying the continuous efficiency of filters, it is of importance to know the strength of the sewage which has been treated and the amount of sludge which it contained. In the table below are given averages of analyses for the year 1893 of the sewage applied to the experimental filters at Lawrence, and of that of the cities and towns in Massachusetts which purify their sewage by intermittent filtration.

*Average of Analyses of the Sewage applied to the Experimental Filters at Lawrence, and of that applied to the Filters used by certain Cities and Towns.*

[Parts per 100,000.]

| SEWAGE.                 | Free Ammonia. | ALBUMINOID AMMONIA. |          |            | Chlorine. | Oxygen Consumed. |
|-------------------------|---------------|---------------------|----------|------------|-----------|------------------|
|                         |               | Total.              | Soluble. | Insoluble. |           |                  |
| Lawrence, . . . . .     | 3.07          | .74                 | .38      | .36        | 7.15      | 3.63             |
| Framingham, . . . . .   | 1.88          | .38                 | .19      | .19        | 4.93      | 5.14             |
| Marlborough, . . . . .  | 2.08          | .62                 | .38      | .24        | 7.85      | 6.29             |
| Gardner, . . . . .      | 1.80          | .45                 | .21      | .24        | 8.11      | 3.94             |
| Westborough,* . . . . . | 1.07          | .19                 | .05      | .14        | 2.27      | 2.72             |

\* Two samples from Westborough were analyzed; the other results (except Lawrence) are averages of semi-monthly analyses.

This table shows that the sewage applied to the experimental filters contains more sludge than the sewage of the other places, and consequently the experimental filters require more attention to prevent clogging than do the several large filters in actual service which receive more dilute sewage.

#### AVERAGE PURIFICATION OF SEWAGE BY THE SEVERAL FILTERS IN 1893.

In the table below are given the average percentages of removal of organic matter (albuminoid ammonia) and of bacteria by the several filters to which ordinary sewage was applied. For the construction and details of operation and results see pages 429-452.

*Average Per Cent. of Albuminoid Ammonia and of Bacteria removed from Sewage by the Several Filters, with Average Rates of Filtration, 1893.*

| NUMBER OF FILTER. | Average Rate of Filtration. (Gallons per Acre Daily for six Days in a Week.) | Per Cent. of Albuminoid Ammonia Removed. | Per Cent. of Bacteria Removed. | NUMBER OF FILTER. | Average Rate of Filtration. (Gallons per Acre Daily for six Days in a Week.) | Per Cent. of Albuminoid Ammonia Removed. | Per Cent. of Bacteria Removed. |
|-------------------|------------------------------------------------------------------------------|------------------------------------------|--------------------------------|-------------------|------------------------------------------------------------------------------|------------------------------------------|--------------------------------|
| 1, . . .          | 106,000                                                                      | 86                                       | 89                             | 11 A, . .         | 58,900                                                                       | 89                                       | 95                             |
| 2, . . .          | 40,500                                                                       | 97                                       | 99.8                           | 13, . . .         | 154,100                                                                      | 91                                       | 95                             |
| 3 A, . .          | 56,300                                                                       | 91                                       | 99.9                           | 14, . . .         | 174,000                                                                      | 95                                       | 96                             |
| 4, . . .          | 32,300                                                                       | 96                                       | 99.9                           | 15 B, . .         | 404,700                                                                      | 77                                       | 77                             |
| 5 A, . .          | 119,000                                                                      | 82                                       | 77                             | 16 B, . .         | 416,200                                                                      | 75                                       | 81                             |
| 6, . . .          | 73,300                                                                       | 91                                       | 99                             | 17 A, . .         | 58,500                                                                       | 95                                       | 99.9                           |
| 7, . . .          | 32,000                                                                       | 92                                       | 99.8                           | 30, . . .         | 55,100                                                                       | 90                                       | 97                             |
| 9 A, . .          | 111,700                                                                      | 92                                       | 99                             | 31, . . .         | 55,100                                                                       | 96                                       | 99.9                           |

These results show that with most of the filters the removal of organic matter was over 90 per cent., while five of them removed 95 per cent. or more. It is to be stated, however, that both the quantitative and qualitative efficiency were in many cases below the normal during the early part of the year. This was owing to the fact that for some time previous the filters had been operated in a manner believed to be unlikely to produce the best results, but tried for the sake of learning the effect of certain methods of operation. The methods of treatment by which the filters resumed their former ability to purify sewage are described and discussed on pages 412-421.

#### PERMANENCY OF SEWAGE FILTERS.

In studying the subject of purification of sewage by filtration a matter of vital importance is the question of the permanency of filters. It is well known that with filters of suitable material sewage may be purified at a rate of more than 100,000 gallons per acre daily, with a removal of over 90 per cent. of the organic matter. It is also known that some of the organic matter of the sewage is stored at and near the surface of the filter, and that under some circumstances there is a certain amount of storage for some distance below the surface. It has been learned that in the case of filters which have regularly filtered sewage at a comparatively high rate it is eventually necessary to spade up the surface in a manner corresponding to ploughing, and later to remove the clogged surface layers and replace them with fresh material. We shall consider the treatment of the upper layers of a sewage filter, say the upper six inches, under the heading of management of filters necessary for their successful operation, and regard the permanency of the filters as the ability of the main body of the sand, below the upper six inches, under proper treatment, to purify sewage for an indefinite time.

In the Annual Report for 1891 it was shown that the storage of organic matter in the filters at that time was steadily increasing. This conclusion was drawn from repeated determinations of nitrogen stored in the sand. During the past two years numerous examinations have been made, but, owing to the unequal distribution of sewage through the material caused by trenching and in other ways, it was found to be practically impossible to obtain results which represent correctly the entire filter. Accordingly the calculations of the quantities of organic matter stored within the filter have been made after another method in 1893. The results of repeated determinations of

nitrogen stored in the sand during the earlier years of the experiments indicated that 30 per cent. of the applied nitrogen was not to be found either in the sand or in the effluent. It probably disappeared in the atmosphere; possibly as nitrogen gas. To the nitrogen found in the average analyses of representative samples of each effluent has been added 30 per cent. of the amount in each case, and the difference between this corrected quantity in the effluent and the quantity of nitrogen in the applied sewage has been taken to represent the amount of nitrogen stored in the filters. In the table below are given the percentages which the nitrogen in the effluents, calculated as described above from the averages of representative analyses, formed of the nitrogen in the applied sewage, by months. The sign minus, of course, indicates a removal of stored nitrogen.

*Per Cent. of Applied Nitrogen that was stored in the Sewage Filters, in 1893.*

| NUMBER<br>OF<br>FILTER. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Averages. |
|-------------------------|----------|-----------|--------|--------|------|-------|-------|---------|------------|----------|-----------|-----------|-----------|
| 1, . . .                | -56      | 5         | -11    | 14     | -21  | -31   | -37   | -41     | 3          | 22       | 28        | 6         | -10       |
| 2, . . .                | 36       | 77        | 80     | 12     | -125 | -86   | -36   | 1       | 2          | -6       | 17        | 11        | -1.5      |
| 3 A, . . .              | 33       | -2        | -2     | 9      | -5   | -59   | -17   | -14     | -          | -        | -         | -         | -7        |
| 4, . . .                | 27       | 62        | 79     | 55     | 49   | 57    | 51    | 15      | 25         | 17       | 31        | 49        | 43        |
| 5 A, . . .              | 7        | 1         | -18    | -5     | -29  | 25    | 29    | 5       | 25         | 25       | 20        | 5         | 7.5       |
| 6, . . .                | 44       | 19        | -29    | -33    | -80  | -66   | -11   | 15      | 53         | 1        | 22        | 27        | -3        |
| 7, . . .                | 42       | 19        | 0      | -7     | -    | -     | -157  | 46      | 27         | 28       | 17        | 22        | 3         |
| 9 A, . . .              | -10      | 1         | -2     | -24    | -42  | -40   | 10    | 3       | 20         | 22       | 33        | -1        | -2.5      |
| 11 A, . . .             | 24       | 11        | -5     | 45     | 27   | 60    | 69    | 60      | -38        | 12       | 4         | 27        | 25        |
| 12 A, . . .             | -6       | -2        | -1     | 4      | -12  | 4     | 32    | 15      | 21         | 23       | 24        | 26        | 11        |
| 13, . . .               | -        | -         | -      | 0      | -18  | -49   | -9    | 3       | 24         | -        | -         | -         | -8        |
| 13 A, . . .             | -        | -         | -      | -      | -    | -     | -     | -       | -          | 0        | 13        | -10       | 1         |
| 14, . . .               | 29       | -13       | -51    | -30    | -94  | -88   | -43   | -1      | 13         | 38       | 67        | -4        | -14       |
| 15 B, . . .             | 57       | 53        | 23     | 23     | 18   | 13    | 16    | 19      | 22         | 22       | 42        | 34        | 28        |
| 16 B, . . .             | 32       | 23        | 14     | 28     | 12   | 27    | 10    | 26      | 29         | 43       | 40        | 36        | 27        |
| 17 A, . . .             | 11       | 19        | -8     | -3     | -59  | -111  | -54   | -8      | 47         | 26       | -28       | 13        | -13       |
| 19, . . .               | 22       | -34       | -49    | -26    | -41  | -17   | -38   | 1       | -16        | -26      | -41       | -19       | -24       |
| 20, . . .               | 16       | 2         | -34    | -11    | -54  | -90   | 98    | -27     | -3         | -3       | 23        | 8         | -23       |
| 21, . . .               | -1       | 5         | -11    | 1      | -61  | -76   | -61   | -46     | -1         | -2       | 22        | 28        | -17       |
| 22, . . .               | 22       | 8         | -34    | -18    | -34  | -8    | 50    | 44      | 48         | 3        | -21       | -3        | 5         |

*Summary and Conclusions.*

1. It will be seen that the only filters in which there was a continued storage of nitrogen were Nos. 4, 15 B and 16 B. These filters represent the extreme limits in the size of materials and the results are explained by the fact that there was an insufficient amount of air for the complete oxidation and nitrification of the applied sewage. From this it follows that the permanency of sewage filters is independent of the size of material, but is directly dependent upon the treatment which they receive.

2. The removal of large amounts of stored organic matter in the spring and early summer months, under favorable conditions, is one of the most marked characteristics of sewage purification by intermittent filtration.

3. It will be noticed that in several cases the storage of nitrogen during the winter months was very slight, while in some instances there was a removal. This is not apparent from the degree of purification of the corresponding effluents, in which the free ammonia was very high, and this seeming discrepancy is explained by the fact that while freezing winter weather interferes with nitrification it does not seriously affect the oxidation of carbonaceous matter to free ammonia.

4. The average results from all the filters, some of which have been in operation regularly for six years, indicate that there was practically no more nitrogen stored in the filters at the end than at the beginning of the year. From this it appears that, with the main body of the sand the same, sewage filters may continue to purify sewage for an indefinite time provided they receive proper treatment to insure sufficient ventilation for the oxidation and nitrification of the applied sewage.

**MANAGEMENT OF FILTERS TO SECURE CONTINUOUS EFFICIENCY.**

An outline of the results obtained by different methods for the conservation of the efficiency of sewage filters is as follows :—

*Systematic Raking followed by Scraping.*

In 1890 it was learned that the interruption of the ventilation of a filter, owing to clogging by the stored organic matter of the sludge at the surface, was prevented, to a great extent, by a systematic weekly raking to a depth of about one inch. Eventually the storage

of sludge in the material disturbed by the weekly raking is so great that ventilation is no longer afforded by this means. It is then necessary, in order to insure the continued efficiency of the filter, to present cleaner material at the surface; and one of the ways by which this may be accomplished is by removing the clogged material by scraping and replacing it with fresh material. (See page 420 with regard to the addition of new material.)

*Filter No. 1.* — This filter is one two-hundredths of an acre in area and contains 63 inches in depth of sand of an effective size\* of 0.48 millimeter. On June 2, 1892, there were removed from the surface 5 inches of clogged material which had been more or less disturbed and mixed together by trenching. This was four years and five months after the filter was first put in operation. No new material was added at this time. The efficiency of the filter was satisfactory during the following months until freezing weather set in. The quality of the effluent improved during March and April, but the surface soon became clogged so that the sewage failed to disappear from the surface in twenty-four hours. On May 5, 1893, a layer of clogged sand, 4 inches in depth, was removed by scraping and new material added to restore the filter to its original depth of 63 inches. The total depth removed in the five years and four months up to this date was 9 inches, or 7.9 cubic yards per million gallons of sewage filtered. The 4-inch layer removed May 5, 1893, was equivalent to 15 cubic yards per million gallons filtered since June 2, 1892. Very good results followed this treatment. The rate of filtration up to July 10 was 120,000 gallons per acre daily for six days in a week; July 11 to August 31, 60,000 gallons; September 1 to 17, 80,000 gallons; September 18 to December 22, 120,000 gallons; and December 23 to 31, 60,000 gallons. During the six months, May to October, inclusive, the average removal of organic matter (albuminoid ammonia) and bacteria from the applied sewage was 93.2 and 95.5 per cent., respectively, while the nitrification was very high. The averages of the analyses of the effluent showed that it contained 3.16 parts per 100,000 of nitrogen as nitrates, which indicates a removal of some of the organic matter stored in the sand.

*Filter No. 6.* — This filter contains 44 inches in depth of mixed coarse and fine sand of an effective size of 0.35 millimeter. The surface has been raked regularly once a week since Jan. 1, 1891.

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\* The "effective size" means that ten per cent. by weight of the sand grains are finer than the diameter given.

On March 29, 1892, 2 inches of clogged material were scraped from the surface and replaced with new material. The filter was spaded over in layers to a depth of 2 feet on May 19, 1892, to break up stratification. The surface became clogged again Sept. 25, 1893, when 2 inches were again scraped off. The total depth of 4 inches removed up to this date is equivalent to 5.8 cubic yards of sand per million gallons of sewage filtered; the 2 inches removed Sept. 25, 1893, are equivalent to 9.7 cubic yards per million gallons filtered since May 19, 1892. During this latter period the average removal of organic matter (albuminoid ammonia) and bacteria from the applied sewage was 94.2 and 99.3 per cent., respectively. The effluent contained, on an average, 2.83 parts per 100,000 of nitrogen as nitrates. The average rate of filtration was 62,400 gallons per acre daily for six days in a week. From September 1 to December 21 the rate was 90,000 gallons, and from December 22 to 31, 50,000 gallons.

*Systematic Scraping when Necessary, without Raking.*

*Filter No. 9 A.* — This filter is 60 inches in depth and contains sand of an effective size of 0.17 millimeter. The upper 6 inches were removed, and the rest of the material taken out and replaced dry May 20, 1892, in order to break up stratification. The surface was raked weekly until July 20, 1892, but since that time it has not been raked, but was scraped whenever the surface became sufficiently clogged to prevent the passage of sewage through the filter. The filter was scraped eleven times from May 20, 1892, to Nov. 16, 1893, and on the latter date the applied sewage failed to disappear just after scraping, indicating a clogging beneath the surface. The filter was restored to its original depth by the addition of new material after scraping on March 14 and Sept. 25, 1893. The total depth removed was 5.54 inches, which is equivalent to 13.8 cubic yards per million gallons of sewage filtered during the period. The rate of filtration, 120,000 gallons per acre daily, for six days in a week, is very high for this material. The average removal of organic matter (albuminoid ammonia) and bacteria from the sewage for the entire period was 94.1 and 98.3 per cent. respectively. The nitrogen as nitrates averaged 2.03 parts per 100,000 in the effluent.

A decided objection to this method of treatment is that the frequent interruption in ventilation causes a temporary decrease in nitrification and an increase in the storage of organic matter. With

long intervals between scrapings this would not be serious; but, as in the case of Filter No. 9 A, there may eventually come a time when the scrapings are so frequent that nitrification does not get fully re-established before clogging occurs again.

It was necessary to scrape, after November 16,  $4\frac{1}{2}$  inches, before the sewage would disappear readily. As the removed sand did not contain sufficient stored organic matter to explain this clogging, its final interpretation must be postponed until something is known of its subsequent history. It is to be mentioned, however, that compactness of the material seemed to be an important feature.

*Systematic Scraping at Regular Intervals, without Raking.*

No experiments upon this point have been made as yet at the Experiment Station, but the sewage filters at Gardner have been treated in this manner for more than two years. The sand in these filters has an effective size of 0.10 to 0.24 millimeter, and the sewage is applied with a two-day interval of rest at an average rate of about 60,000 gallons per acre daily. About one-eighth inch of scum and clogged sand is removed once in ten days to two weeks. After scraping off the stored sludge the sand is raked to a depth of 1 to  $1\frac{1}{2}$  inches to loosen the material. This treatment appears to be very satisfactory.

*Systematic Raking followed by Ploughing.*

Upon the application of sewage to filters of coarse sand the sludge passes deeper into the material than in the case of filters of fine sand; eventually a clogging occurs at a point just beneath that reached in the weekly raking (1 inch deep). Under these circumstances the surfaces have been spaded over in a manner corresponding to ploughing.

*Filter No. 3 A.*—This filter contains 30 inches in depth of coarse sand above 30 inches of fine sand. The effective sizes are 0.48 and 0.08 millimeter, respectively. The surface was spaded over 6 inches deep Oct. 19, 1892, and, with the aid of weekly raking, the applied sewage disappeared promptly until August, 1893, when the filter became clogged again. The surface was spaded over 6 inches deep August 14, after which the applied dose of sewage, equivalent to 60,000 gallons per acre daily for six days in a week, disappeared promptly, and the quality of the effluent steadily improved up to September 1, when the experiment was discontinued.



*Filter No. 5 A.*—This filter contains 63 inches in depth of screened gravel of an effective size of 1.40 millimeters. Clogging beneath the surface became apparent June 12, 1893, and was relieved by raking 2 inches deep. The rate of filtration was 120,000 gallons per acre daily for six days in a week. Sub-surface clogging appeared again September 15, when the surface was spaded over 6 inches deep. On October 30 the rate was increased to 160,000 gallons per acre, and clogging began to appear again the first of December.

Under this method of treatment it would be necessary, if a high rate of filtration were maintained, to resort eventually to scraping, as was the case with Filter No. 5 A in December.

### *Trenching.*

*Filter No. 2.*—This filter contains 60 inches in depth of very fine sand of an effective size of 0.08 millimeter. In the winter of 1892-93 the surface of the filter became very badly clogged, and on March 2 there were dug two circular trenches, each one foot wide and two feet deep, one and a half and five feet, respectively, from the edge of the filter. These trenches were filled to within three inches of the top with sand of an effective size of 0.19 millimeter. The prescribed dose of 40,000 gallons per acre daily for six days in a week was then taken without difficulty and the quality of the effluent steadily improved. On September 1 the dose was increased to 60,000 gallons. During October the trenches gradually showed the effect of clogging, and finally were unable to take the prescribed dose. At the same time the free ammonia in the effluent began to increase. On October 30 the upper two inches of sand in the trenches were removed and replaced with fresh material. This afforded but little relief, owing to a clogging further down in the filter, as is explained beyond. The sand removed was equivalent to 7.9 cubic yards per million gallons of sewage filtered since March 2, 1893, and contained 118 parts per 100,000 of albuminoid ammonia. The average removal of organic matter (albuminoid ammonia) and bacteria from the applied sewage during this time was 95.7 and 99.7 per cent., respectively. The effluent contained on an average 2.86 parts per 100,000 of nitrogen as nitrates, which indicates a removal of some of the organic matter stored in the sand during the winter months. The average rate of filtration was 43,000 gallons per acre daily for six days in a week.

The trenches in this filter probably doubled the quantity of sewage which could be successfully treated, and moreover caused a marked improvement in the quality of the effluent.

### *Construction of Trenches.*

When coarse sand is placed in trenches dug in finer sand some of the sludge of the applied sewage in time works down to the fine sand at the junction, where the gradually increasing storage causes an increase in the capillary attraction, and eventually so large a proportion of the space between the sand grains is constantly filled with water that the ventilation is seriously impaired and the frictional resistance is so great that both the qualitative and quantitative efficiency of the filter are crippled.

Filter No. 2 became clogged in this manner, and on Dec. 2, 1893, the coarse sand was removed from the trenches and also two and a half inches of the fine sand beneath it. After raking the sides and the bottom of the trenches, a layer five inches in depth of thoroughly mixed coarse and fine sand, with the coarse gradually decreasing downward, was put back, with a view to preventing the occurrence of any sharply dividing line in the difference in capillary attraction. As far as can be judged at the time of writing the effect upon the filter was very beneficial. In the case of deep trenches, where much of the sewage passes through the sides, it would probably be desirable to treat the sides in a somewhat similar manner.

Some experiments have been made, showing comparisons of the capillarity and other physical characteristics of coarse and fine sand and several mixtures of the two. The materials (Nos. 1 and 2 sands) were dried and thoroughly mixed. In the table below are given the mechanical composition, effective size, uniformity coefficient, per cent. of open space and specific gravity, as well as the capillarity in each case. The capillarity was determined by finding the amount of water held in the pores of the sand after draining twenty-four hours, and it is instructive to note that the mixtures of one part coarse and three parts fine and equal parts of coarse and fine held more water than the fine alone, while the other mixture held only a little less.

*Mechanical Composition of Sands.*

| DIAMETER IN MILLIMETERS.  | PER CENT. |       |                              |                               |                                  |
|---------------------------|-----------|-------|------------------------------|-------------------------------|----------------------------------|
|                           | Coarse.   | Fine. | One part Coarse, three Fine. | Equal parts, Coarse and Fine. | Three parts Coarse and one Fine. |
| Finer than 5.9, . . . . . | 100.      | -     | -                            | -                             | -                                |
| " 3.9, . . . . .          | 98.       | -     | 100.                         | 100.                          | 100.                             |
| " 2.0, . . . . .          | 93.       | -     | 99.                          | 94.                           | 90.                              |
| " .93, . . . . .          | 32.0      | -     | 89.                          | 75.                           | 61.                              |
| " .46, . . . . .          | 8.0       | 100.  | 72.                          | 54.                           | 30.                              |
| " .32, . . . . .          | 3.3       | 98.   | 69.                          | 51.                           | 25.                              |
| " .18, . . . . .          | .9        | 88.   | 62.                          | 46.                           | 22.                              |
| " .10, . . . . .          | .4        | 24.   | 15.                          | 13.                           | 6.                               |
| " .08, . . . . .          | -         | 10.   | 6.                           | 5.                            | 3.                               |
| " .04, . . . . .          | -         | 2.    | 2.                           | 1.                            | -                                |

*Physical Characteristics.*

|                                            | Effective Size.<br>Millimeter. | Uniformity Coefficient. | Per Cent. Open Space. | Specific Gravity. |
|--------------------------------------------|--------------------------------|-------------------------|-----------------------|-------------------|
| Coarse, . . . . .                          | 0.48                           | 2.5                     | 40.                   | 1.64              |
| Fine, . . . . .                            | 0.08                           | 2.0                     | 44.                   | 1.50              |
| One part coarse and three fine, . . . . .  | 0.09                           | 2.1                     | 37.                   | 1.68              |
| Equal parts, coarse and fine, . . . . .    | 0.10                           | 3.7                     | 34.                   | 1.74              |
| Three parts coarse and one fine, . . . . . | 0.13                           | 6.6                     | 35.                   | 1.73              |

*Per Cent. of Total Open Space in each Foot occupied by Water after being filled and then drained for Twenty-four Hours.*

|                        | Coarse. | Fine. | One Part Coarse, Three Parts Fine. | Equal Parts, Coarse and Fine. | Three Parts Coarse, One Part Fine. |
|------------------------|---------|-------|------------------------------------|-------------------------------|------------------------------------|
| Upper foot, . . . . .  | 15      | 39    | 38                                 | 38                            | 26                                 |
| Second foot, . . . . . | 15      | 45    | 51                                 | 56                            | 32                                 |
| Third foot, . . . . .  | 16      | 64    | 68                                 | 71                            | 44                                 |
| Fourth foot, . . . . . | 16      | 84    | 97                                 | 88                            | 68                                 |
| Fifth foot, . . . . .  | 18      | 100   | 100                                | 100                           | 88                                 |

*Resting.*

*Filter No. 4.* — This filter contains 60 inches in depth of fine river silt of an effective size of 0.04 millimeter and has received sewage since June 24, 1889, in a trench of coarse mortar sand. This trench covers one-third the area of the filter, is 14 inches deep, and is filled to within 3 inches of the top with the coarse sand. In the winter of 1892–93 the trench became clogged and unable to take the dose of 40,000 gallons per acre daily for six days in a week. On March 6 the upper 2 inches of sand in the trench, containing 75 parts per 100,000 of albuminoid ammonia, were removed. This was a total removal of  $3\frac{1}{2}$  inches since June 24, 1889, and equivalent to 3.79 cubic yards per million gallons; the 2 inches removed March 6, 1893, were equivalent to 9.3 cubic yards per million gallons filtered since May 9, 1892, the date of the first removal. This did not afford relief, and the coarse sand was taken out of the trench, the upper half inch of the fine sand beneath it was removed and the coarse sand replaced. Clogging again occurred in May, and a new trench was constructed June 2, the old one being allowed to rest. Analyses of the sand showed that there was a reduction of 39 per cent., from June 2 to August 16, of the albuminoid ammonia stored in the trench. Another analysis on October 30 showed no farther reduction, but the sewage was applied to the original trench from that date throughout the year without difficulty. The rate of filtration since June 2 has been 30,000 gallons per acre daily for six days in a week. The average removal of organic matter (albuminoid ammonia) and bacteria from the applied sewage, May, 1892, to October, 1893, inclusive, was 92.9 and 99.993 per cent., respectively. For November and December, 1893, these figures became 98.2 and 99.999, respectively. The nitrogen as nitrates in the effluent averaged 1.09 and 2.14 parts per 100,000, respectively, during the two periods.

The construction of double trenches, allowing each to work and rest alternately, in periods, is of much practical value; and, moreover, the removal of stored organic matter by simple resting indicates that this inexpensive method is worthy of careful consideration in the treatment of large areas of clogged filtering material.

### *Addition of New Material.*

For some time it has been known that the passage of sewage through sand increases the amount of stored organic matter, which forms a sticky coating around the sand grains and thereby increases the capillary attraction. Accordingly, when new material with grains of the same size and original composition is put upon old material to take the place of clogged material removed by scraping the effect is similar to placing coarse sand above fine, and the result is a clogging at the junction. This was found to be the case in Filters Nos. 1 and 6, which indicated furthermore that the finer the material and the nearer the junction was to the surface the quicker the clogging became manifested. To remedy this the filters were spaded over, the old and new material mixed together, so as to break up the layer at the dividing line between the materials of unlike capillary attraction, and satisfactory results followed.

### *The Management of Sewage Filters with Regard to Winter Weather.*

The purification of sewage by intermittent filtration is ordinarily attended with more difficulties during the freezing winter weather than during the remainder of the year, owing to an apparent diminution in the activity of the micro-organisms in the presence of frost; to the less favorable conditions for ventilation because freezing interferes with draining, and the pores of the sand are more or less filled with frost; and to the danger of the sewage freezing to the sand before it disappears, whereby further filtration is impossible until a thaw comes. It is therefore of the utmost importance that the treatment of the filters be such that the conditions for operation be as favorable as possible during the winter.

Most of the experimental filters received their preparation for the winter on December 2, and on the following day severe winter weather began. The filters showed great improvement in the readiness with which they took the applied sewage, but the improvement in the quality of the effluent was far less than would have been the case in warmer weather. This indicates that the filters should be prepared for the winter sufficiently early to be in their best condition in every way when freezing weather begins. It does not appear to be advisable to postpone this treatment in Massachusetts after the 1st of November.

In regard to the preparation necessary, it may be stated that the

clogging should be removed as far as practicable, and in a majority of cases the surface can with great advantage be arranged in alternate ridges and trenches. The ordinary winter sewage is sufficiently warm to melt some of the snow in the trenches, but in so doing becomes so chilled that in many cases a sheet of ice is formed beneath the unmelted snow and above the sand in the trench. The sewage will slowly pass into the sand and form in this way a very inexpensive and effective winter cover. It is also to be mentioned that at Framingham the filters, which were planted with corn (maize), were afforded such covers by allowing the snow and ice to rest upon the corn hills.

Owing to the limited area of the experimental filters there is but little opportunity for lateral filtration (a very important feature in large filters), and it is not practicable to ridge and trench the surface of most of the Lawrence filters because the sewage would pass through in places too quickly. It appears that large filters in actual practice are much less difficult to operate in winter weather than the experimental filters.

### *Summary and Conclusions.*

The several methods of managing filters, with particular reference to the removal of clogging in the surface layers, which have been applied, with varying results, may be summarized as follows:—

1. Systematic raking, with occasional harrowing or ploughing, is very satisfactory, particularly for coarse materials.

2. Systematic scraping at regular intervals (followed by raking to loosen the material) gives very good results, especially for fine materials.

3. Systematic scraping when necessary, without raking or harrowing, is not advisable.

4. The efficiency of very fine material (clogged or not clogged) is much increased by trenching with coarse material.

5. Such trenches should contain carefully graded materials at the bottom to prevent clogging at the junction of the coarse and fine sand.

6. When new material is put on to old to replace clogged material removed by scraping, it is always advisable to mix the old and the new together in order to prevent clogging at the junction of layers of unlike capillary attraction.

7. The removal of stored organic matter by resting for a limited

period is sufficiently great to render this simple and inexpensive method worthy of careful consideration in cases of clogging where the available area is not too limited. It may be mentioned here that the depth of material necessary to be removed from the surface of several of the experimental filters would doubtless have been considerably less if they had been allowed to rest for a short time.

8. It is important that the treatment of filters be such that the conditions of operation be as favorable as possible during the cold winter weather.

9. Great care should be taken, especially in the case of filters of fine material, that the capacity of the filter be not taxed during the winter months to such an extent that more organic matter is stored throughout the sand than can be removed during the spring and early summer, which is the period of highest nitrification.

#### EXPERIMENTS UPON THE RAPID FILTRATION OF SEWAGE FROM WHICH THE SLUDGE HAS BEEN REMOVED BY DIFFERENT METHODS.

The question of clogging has been considered in the preceding pages with regard to the removal of sludge after its application to and partial storage in the sand. Another aid to prevention and relief is the removal of as much of the sludge as possible before the application of the sewage to the filter. This may be done by different treatments as follows:—

I. By rapid filtration through coarse gravel, with the aid of a current of air drawn through the gravel.

II. By chemical precipitation.

III. By sedimentation.

IV. By mechanical devices, such as very fine screens or wire cloth. (Results as yet incomplete.)

After treating sewage by one of the first three of these different methods it has been in each case applied to a filter of sand 5 feet deep, having an effective size of grain of 0.17 to 0.19 millimeter.

#### *I. (Filters Nos. 12 A, 15 B and 16 B.)*

*Filters Nos. 15 B and 16 B* are each 65 inches in depth and contain gravel stones of an effective size of 5.10 millimeters. They were put in operation July 25, 1892. A current of air has been drawn through No. 15 B, by means of an aspirator attached to the tank near the bottom, since March 18, 1893, and through No. 16 B since Jan. 16, 1893. The outlet from each filter has been trapped.

The surfaces were not disturbed until the middle of July, 1893, about a year after they were first put in operation. They were each raked 3 inches deep four different times, to remove clogging, between the middle of July and September 1. After September 1, they were raked regularly once a week until October 26, since which date they have been raked 3 inches deep daily. During November and December there was evidence of sub-surface clogging and each filter was spaded over 6 to 8 inches deep on several occasions. No material has been removed from either filter.

*Filter No. 12 A* contains 60 inches in depth of sand of an effective size of 0.19 millimeter, and receives the effluent of Nos. 15 B and 16 B. Since March 24 it has been scraped when clogged, but not raked. The clogged sand has been washed and replaced. The filter has been scraped on an average once in five days, and the average depth of clogged sand removed was 0.24 inch. Sub-surface clogging made it necessary to spade over the upper six inches of sand after scraping on September 27 and December 12 and 27. The results are summarized beyond.

### *II. (Filter No. 19.)*

This filter is also 60 inches deep, and the sand has an effective size of 0.17 millimeter. It has received the supernatant liquid from sewage after treatment with alum (1,000 pounds per million gallons and allowed to settle four hours). Since October 23 it has been scraped after the same manner as No. 12 A. The average period between scrapings was ten days and the average depth removed was 0.47 inch. Up to December 20 the filter had twice been spaded over 6 inches deep to remove sub-surface clogging. The rate of filtration, 640,000 gallons per acre daily for six days in a week, overtaxed the capacity of the filter, which was allowed to rest for two weeks beginning December 23. The results are summarized beyond.

### *III. (Filter No. 13 A.)*

This filter was constructed on Sept. 27, 1893, and contains 60 inches in depth of sand of an effective size of 0.19 millimeter. It received the supernatant liquid from sewage which had been allowed to settle four hours. It has been scraped on an average once in six days, and the average depth removed was 0.37 inch. In December the sand was spaded over to a depth of 6 inches, three times, to remove sub-surface clogging. The rate of filtration, 480,000 gallons



per acre daily for six days in a week, overtaxed the filter, which was allowed to rest for two weeks beginning December 23. The results are summarized below.

*Quantitative Efficiency — Average Rates of Filtration.*

(Gallons per acre daily for six days in a week.)

| NUMBER OF FILTER. | JAN. 1 TO DEC. 31,<br>1893. | OCT. 1 TO DEC. 31,<br>1893. |
|-------------------|-----------------------------|-----------------------------|
| 12 A, . . . . .   | 819,900                     | 960,000                     |
| 13 A, . . . . .   | -                           | 416,300                     |
| 15 B, . . . . .   | 404,700                     | 480,000                     |
| 16 B, . . . . .   | 415,200                     | 480,000                     |
| 19, . . . . .     | 267,200                     | 554,000                     |

*Qualitative Efficiency — Average Percentage\* of Removal of Organic Matter and Bacteria.*

|                                                                            | JAN. 1 TO DEC. 31,<br>1893. |           | OCT. 1 TO DEC. 31,<br>1893. |           |
|----------------------------------------------------------------------------|-----------------------------|-----------|-----------------------------|-----------|
|                                                                            | Albuminoid<br>Ammonia.      | Bacteria. | Albuminoid<br>Ammonia.      | Bacteria. |
| From sewage by Filter No. 15 B, . . . . .                                  | 77.3                        | 77.4      | 79.9                        | 84.0      |
| From sewage by Filter No. 16 B, . . . . .                                  | 75.2                        | 80.8      | 70.5                        | 79.8      |
| From effluent of Filters Nos. 15 B and 16 B by Filter<br>No. 12 A.         | 81.2                        | 98.9      | 86.8                        | 99.9      |
| From sewage by Filters Nos. 15 B or 16 B and No.<br>12 A.                  | 95.5                        | 99.8      | 96.7                        | 99.9      |
| From sewage by chemical precipitation, . . . . .                           | 52.4                        | 84.3      | 55.2                        | 81.6      |
| From clarified sewage (after chemical precipitation),<br>by Filter No. 19. | 89.0                        | 95.8      | 78.7                        | 97.9      |
| From sewage by chemical precipitation and Filter<br>No. 19.                | 94.6                        | 99.2      | 90.1                        | 99.6      |
| From sewage by sedimentation, . . . . .                                    | -                           | -         | 18.2                        | 12.0      |
| From clarified sewage (after sedimentation) by Fil-<br>ter No. 13 A.       | -                           | -         | 89.4                        | 98.6      |
| From sewage by sedimentation and Filter No. 13 A,                          | -                           | -         | 91.3                        | 98.8      |

\* Several of the percentages in this table differ a little from those presented on page 101 of Senate Document No. 4 for 1894, owing to a slight revision of, and an extension of the period covered by, the results.

*Summary and Conclusions.*

1. Of the three methods given above for the removal of sludge, filtration through coarse gravel at a very rapid rate, and with the aid of a current of air drawn through the gravel, gave the greatest purification. Furthermore, it has the advantage that it burns up the sludge to a large extent and does not call for additional means for sludge disposal.

2. The removal of sludge by sedimentation enables filters of fine material to be operated at higher rates than filters which receive ordinary sewage. It appears that it would be advisable to employ sedimentation in many large filters where the sewage is strong and the filters are not cultivated.

3. The aid received from the removal of sludge by chemical precipitation does not appear to be sufficient to justify the additional cost.

4. Of the three filters of fine sand which receive sewage from which the sludge has been partly removed by different methods, No. 12 A received the best purified sewage and gave the highest efficiency both from a qualitative and a quantitative point of view. This filter also is the only one capable of continuing to work at the rates given above.

5. Upon studying the several methods of obtaining a well purified effluent from sewage we find that the average rate of filtration for the combined area of Filters Nos. 12 A, 15 B and 16 B was 320,000 gallons per acre daily for six days in a week. This is the best result yet obtained with the experimental filters, and this system of double filtration with the aid of a current of air appears to be capable of application to the purification of sewage on a large scale.

#### SUB-SURFACE APPLICATION OF SEWAGE.

*Filter No. 7.* — This filter contains 44 inches in depth of mixed coarse and fine sand of an effective size of 0.35 millimeter, above which are 10 inches of loam and 6 inches of soil. The sub-surface drain pipe is 6 inches in diameter, with open joints every 2 feet, and is 18 inches below the surface. This pipe became clogged and on April 20 was taken up and cleaned. The sludge removed contained 75 per cent. of the insoluble albuminoid ammonia applied since the pipe was cleaned and relaid in October, 1892. The pipes were again relaid July 8 and sewage applied at the rate of 40,000 gallons per acre daily for six days in a week. The drain pipe is gradually becoming clogged, and since December 1 the full dose could not be applied.

The nitrification was incomplete in August, and the ventilation has been increased by aspiration since September 1. The quality of the effluent has improved and remains very satisfactory.

From the experiments upon Filter No. 7 and observations upon

the sub-surface filters at Lenox and Wellesley we may draw the following conclusions:—

1. From a chemical and biological point of view no marked difficulties attend the purification of sewage applied beneath the surface.

2. As much of the sludge as possible should be removed from the original sewage by screens and sedimentation before applying it to the sub-surface.

3. The sub-surface pipes should be provided with outlet gates at the lower end, opposite the point of application, so that they may be flushed out from time to time to remove the accumulated sludge.

4. In most cases, to avoid clogging, the drain pipe should be surrounded with stones or coarse gravel, and in order to prevent the sand from filling the spaces the gravel should be surrounded with successive layers of material of intermediate and gradually decreasing size.

#### EXPERIMENTS WITH SAND CLOGGED BY SEWAGE.

*Filter No. 11A.*—This filter was filled in April, 1892, with 5 feet of material which had been scraped from the surface of Filter No. 6 because it was clogged. Aided by a current of air it began to do good work in a few months and in 1893 it filtered sewage at the rate of 60,000 gallons per acre daily for six days in a week with an effluent as well purified as that from some filters of clean material. The purification fell off in the summer, owing to clogging at the surface. In August the upper 3 inches were removed and the quality of the effluent steadily improved and remained satisfactory throughout the year.

This experiment offers a strong confirmation of the conclusion already drawn with regard to the injurious effect of the presence of layers of unlike material in a filter. (Compare Annual Report for 1892, pages 403 and 409, and also the sections in the present Report on the construction of trenches and the addition of new material, pages 417 and 420.) This material, just before its removal, and when it formed a portion of the upper layer 2 inches in depth of Filter No. 6, remained saturated with water and ventilation was precluded because the cleaner sand beneath it was unable to draw the water from it. When placed by itself, however, it drained, allowed air to enter the pores and oxidation processes in time became re-established. In Filter No. 11 A the upper portion eventually contained so much stored organic matter that it remained saturated and the

comparatively clean but actually dirty and partly clogged sand beneath it could not withdraw the water from its pores to allow the entrance of air. There is no reason to believe, moreover, that this portion which was removed would not in time make an efficient filter if placed by itself. This experiment with others shows that the clogging of a sewage filter does not mean the storage in the material of any definite amount of organic matter, but that it arises from differences in capillary attraction of adjoining layers. While it is true of course that increased storage of organic matter means increased capillarity, it is also true that marked differences in capillary attraction occur in unlike material containing very little or no organic matter.

#### THE EFFECT OF POLARITE IN A FILTER ON THE REMOVAL OF COLOR FROM SEWAGE CONTAINING DYE STUFF.

*Filter No. 14.*—This filter has contained since Jan. 21, 1893, a layer of polarite\* 7 inches deep, the top of which was 6 inches below the surface. From February 13 to March 22, Patent Blue† equivalent to 0.33 part per 100,000 was put into the sewage, which was applied to the filter at the rate of 160,000 gallons per acre daily for six days in a week. The effluent was slightly colored after a few days, and the color became quite marked at the end of 38 days. The filter was then operated as usual without the dye stuff in the sewage and it was not until August 26 that the effluent became free from the color which had been stored in the filter.

During this time Filter No. 13, of the same construction as No. 14, without polarite, received the same treatment as the latter. The effluent of each was uniformly well purified with high nitrification.

Beginning on August 26, Scarlet 2R (another aniline dye), equivalent to 0.44 part per 100,000, was added to the dose of each filter. The applied sewage had a strong red color. On the second day the effluent of No. 13 (without polarite) showed a pink tint and

#### \* Analysis of polarite by Professor Roscoe:—

|                                          |        |
|------------------------------------------|--------|
| Magnetic oxide of iron, . . . . .        | 53.85  |
| Alumina, . . . . .                       | 5.68   |
| Magnesia, . . . . .                      | 7.55   |
| Water, with a trace of carbon, . . . . . | 5.41   |
| Silica, . . . . .                        | 25.50  |
| Lime, . . . . .                          | 2.01   |
|                                          | <hr/>  |
|                                          | 100.00 |

† Trade name for an aniline dye.

contained about 20 per cent. of the color in the applied sewage on the twelfth day of the application. The first appearance of color in the effluent of No. 14 was on the twenty-second day, and the color had not become marked on the twenty-eighth day, when the application of this dye was stopped.

On September 24 Patent Blue was added to the dose of each filter (0.33 part per 100,000 — the same as applied to No. 14 during the winter months), and the effluent of No. 13 was strongly colored on the first day, while that of No. 14 was tinted only very slightly.

### THE REMOVAL OF BACTERIA.

The number of bacteria in the effluent of a sewage filter depends upon the size of the material and the condition of the filter. With filters of very fine sand such as Nos. 2 and 4 it is probable that no bacteria pass through from top to bottom. When the nitrification is very incomplete and there has been considerable storage of organic matter in the sand, the number of bacteria in the effluent frequently increases. These bacteria, however, belong to one or more hardy species which are able to multiply within the filter. Thus, in the case of Filter No. 2 in March, 1893, the bacteria in the effluent were comparatively high and were nearly a pure culture of a liquefying, fluorescent bacillus.

Filters Nos. 6 and 9 A, when operated under the most favorable conditions, appear to allow no bacteria to pass through from top to bottom. When operated at high rates of filtration, however, a very small percentage of the applied bacteria, as a rule, passes through the filters.

With materials as coarse as those in Filters Nos. 1, 5 A and 15 B there are always some bacteria which pass directly through the filter. The number of bacteria decreases as the distance from the point of application to the underdrains and the time taken to travel this distance increases.

With regard to seasonal effect, it is to be stated that generally speaking the winter months are the time of least efficiency, because the conditions for nitrification and other processes are then least favorable. When a filter is in good condition it is possible to obtain normal bacterial results in the winter, and as most increases in the number of bacteria in the effluent come from disarrangements of the functions of the filters, periods of unusually low bacterial removal may be found at all times of the year.

## WORK OF THE FILTERS FOR 1893.

The experimental filters used during 1893 for sewage purification have been mainly the ones which have been fully described in previous Reports of the Board. In the following table are given the descriptions of the materials used. This is followed by an outline of the history of each filter and the monthly averages of the analyses.

*Construction of Experimental Sewage Filters studied in 1893.*

| NUMBER OF FILTER. | DIMENSIONS OF FILTERS.    |                           |                               | SIZE OF SAND.                                             |                                                           | Manner of Filling.                                                                       | In Operation since— | REMARKS.                                                                     |
|-------------------|---------------------------|---------------------------|-------------------------------|-----------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------------------------------------|---------------------|------------------------------------------------------------------------------|
|                   | Depth of Sand.<br>Inches. | Mean Diameter.<br>Inches. | Area in Fractions of an Acre. | Effective Size in Millimeters, 10 per Cent. Finer than—   | Uniformity Coefficient.                                   |                                                                                          |                     |                                                                              |
| 1, . .            | 63                        | 200                       | $\frac{1}{800}$               | .48                                                       | 2.4                                                       | Wet.                                                                                     | Jan. 10, 1888.      | - -                                                                          |
| 2, . .            | 60                        | 200                       | $\frac{1}{800}$               | .08                                                       | 2.0                                                       | Wet.                                                                                     | Dec. 19, 1887.      | Contains two trenches of coarse sand.                                        |
| 3 A, .            | 60                        | 200                       | $\frac{1}{800}$               | $\left\{ \begin{array}{l} .48 \\ .08 \end{array} \right.$ | $\left\{ \begin{array}{l} 2.4 \\ 2.0 \end{array} \right.$ | $\left\{ \begin{array}{l} \text{Dry.} \\ \text{Dry.} \\ \text{Wet.} \end{array} \right.$ | Jan. 6, 1890.       | Discontinued Sept. 1, 1893.                                                  |
| 4, . .            | 60                        | 200                       | $\frac{1}{800}$               | .04                                                       | 2.7                                                       | Wet.                                                                                     | Dec. 19, 1887.      | Contains two trenches of coarse sand.                                        |
| 5 A, .            | 63                        | 200                       | $\frac{1}{800}$               | 1.40                                                      | 2.4                                                       | Dry.                                                                                     | Sept. 14, 1891.     | - -                                                                          |
| 6, . .            | 44                        | 200                       | $\frac{1}{800}$               | .35                                                       | 7.8                                                       | Wet.                                                                                     | Jan. 12, 1888.      | - -                                                                          |
| 7, . .            | 44                        | 200                       | $\frac{1}{800}$               | .35                                                       | 7.8                                                       | Wet.                                                                                     | Jan. 14, 1888.      | Covered with 16 inches of loam and soil; sewage applied beneath the surface. |
| 9 A, .            | 60                        | 200                       | $\frac{1}{800}$               | .17                                                       | 2.0                                                       | Dry.                                                                                     | Nov. 18, 1890.      | - -                                                                          |
| 11 A, .           | 60                        | 20                        | $\frac{1}{80,000}$            | .35                                                       | 7.8                                                       | Dry.                                                                                     | Mar. 30, 1892.      | Filled with clogged material from No. 6.                                     |
| 12 A, .           | 60                        | 20                        | $\frac{1}{80,000}$            | .19                                                       | 2.0                                                       | Dry.                                                                                     | July 25, 1892.      | - -                                                                          |
| 13, . .           | 63                        | 20                        | $\frac{1}{80,000}$            | .48                                                       | 2.4                                                       | Wet.                                                                                     | Feb. 16, 1888.      | Discontinued Sept. 27, 1893.                                                 |
| 13 A, .           | 60                        | 20                        | $\frac{1}{80,000}$            | .19                                                       | 2.0                                                       | Dry.                                                                                     | Sept. 27, 1893.     | - -                                                                          |
| 14, . .           | 63                        | 20                        | $\frac{1}{80,000}$            | .48                                                       | 2.4                                                       | Wet.                                                                                     | Feb. 16, 1888.      | Contains layer of polarite.                                                  |
| 15 B, .           | 65                        | 20                        | $\frac{1}{80,000}$            | 5.10                                                      | 2.0                                                       | Dry.                                                                                     | July 25, 1892.      | Constantly aerated.                                                          |
| 16 B, .           | 65                        | 20                        | $\frac{1}{80,000}$            | 5.10                                                      | 2.0                                                       | Dry.                                                                                     | July 25, 1892.      | Constantly aerated.                                                          |
| 17 A, .           | 60                        | 20                        | $\frac{1}{80,000}$            | .17                                                       | 2.0                                                       | Wet.                                                                                     | Jan. 28, 1890.      | Contains layers of marble dust.                                              |
| 19, . .           | 60                        | 20                        | $\frac{1}{80,000}$            | .17                                                       | 2.0                                                       | Wet.                                                                                     | Jan. 28, 1890.      | - -                                                                          |
| 25, . .           | 120                       | 20                        | $\frac{1}{80,000}$            | -                                                         | -                                                         | Wet.                                                                                     | Jan. 1, 1890.       | Filled with loam and soil. Contains carcass of dog.                          |
| 30, . .           | 30                        | 17                        | $\frac{1}{27,000}$            | .48                                                       | 2.4                                                       | Dry.                                                                                     | May 31, 1890.       | - -                                                                          |
| 31, . .           | 30                        | 17                        | $\frac{1}{27,000}$            | .17                                                       | 2.0                                                       | Dry.                                                                                     | May 31, 1890.       | - -                                                                          |
| 32, . .           | 30                        | 17                        | $\frac{1}{27,000}$            | .17                                                       | 2.0                                                       | Dry.                                                                                     | Dec. 5, 1891.       | - -                                                                          |

## FILTER No. 1.

At the beginning of the year the surface of this filter, unprotected from the weather, was considerably clogged by organic matters stored in the sand, and during the extreme cold weather of January the nitrification was very slight, while the ammonias in the effluent became exceptionally high. The applied sewage, equivalent to 120,000 gallons per acre daily for six days in a week, at times disappeared very slowly and in a few instances froze to the sand. In this case the ice was removed with a pick and shovel in order to keep the filter in action. In February the quality of the effluent improved somewhat, but was still poor, owing to imperfect ventilation and probably to the passage of the sewage through portions of the filter where there was the least frost. From March 8 until the middle of April, ventilation was increased by drawing air through the sand by means of an aspirator attached to the outlet pipe, the end of which was trapped. The quality of the effluent improved until about the first of May, when the spring rains caused the surface to be partially covered for several days, but then began to deteriorate, and on May 5, 4 inches of discolored and partially clogged sand were removed and 9 inches of fresh material were added to bring the filter up to its original depth of 63 inches. Nitrification soon became high and remained so during the summer in the absence as well as in the presence of aspiration. The ammonias in the effluent became low and it is to be stated that in July and August the albuminoid ammonia was caused in part by the presence of small white worms which appeared to live in the underdrains. During the warm weather there was a removal, by nitrification, of considerable organic matter which had been stored in the sand. In October the ammonias began to increase in the effluent, owing to the interruption in the ventilation caused by clogging, at the junction of layers of old and new sand. On December 2, the surface was spaded over, 12 inches deep, in two layers of 6 inches each. The quality of the effluent improved up to the middle of the month, when the very cold weather interfered with the purification, but not with the quantitative efficiency. The poorest result of the month was on December 19, when the albuminoid ammonia in the effluent was .2260 part. The cause of this doubtless was that the sewage passed through holes in the frost made at the points where the warm sewage first reached the sand.

*Effluent from Filter No. 1.*

[Parts per 100,000.]

| 1893.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE. DEG. F. |           | Length of Time Sewage Remained on Surface.<br>—<br>Hours and Minutes. | Average Depth of Frost.<br>—<br>Inches. | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS — |          | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|---------------------------------------------------------------------|----------------------|-----------|-----------------------------------------------------------------------|-----------------------------------------|-------------|--------|----------|-------------|-----------|---------------|----------|------------------|--------------------------------|
|              |                                                                     | Sewage.              | Effluent. |                                                                       |                                         | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrate.      | Nitrite. |                  |                                |
| January, .   | 120,000                                                             | 45                   | 34½       | 3h.                                                                   | 7½                                      | Slight.     | .71    | 2.5000   | .2910       | 7.33      | .0725         | .0000    | 1.86             | 329,000                        |
| February, .  | 120,000                                                             | 45                   | 35½       | 1h.                                                                   | 5½                                      | Slight.     | .47    | 1.6900   | .2035       | 5.83      | .2675         | .0365    | 1.35             | 298,750                        |
| March, .     | 120,000                                                             | 43½                  | 37½       | 1h. 30m.                                                              | 3                                       | Slight.     | .40    | .6200    | .1042       | 5.77      | 1.2200        | .0394    | .72              | 63,937                         |
| April, .     | 120,000                                                             | 46                   | 43½       | 1h. 30m.                                                              | 0                                       | V. sl.      | .29    | .1225    | .0675       | 6.29      | 1.4575        | .0036    | .45              | 37,625                         |
| May, .       | 102,000                                                             | 55                   | 55        | 2h. 30m.                                                              | 0                                       | V. sl.      | .32    | .1406    | .0721       | 5.69      | 2.5137        | .0188    | .48              | 57,625                         |
| June, .      | 120,000                                                             | 69                   | 67½       | 1m.                                                                   | 0                                       | V. sl.      | .29    | .0363    | .0548       | 9.58      | 3.2333        | .0191    | .41              | 48,625                         |
| July, .      | 75,000                                                              | 73                   | 74        | 1m.                                                                   | 0                                       | None.       | .27    | .0093    | .0488       | 8.11      | 4.0050        | .0082    | .32              | 33,000                         |
| August, .    | 54,400                                                              | 68                   | 74        | 1m.                                                                   | 0                                       | None.       | .19    | .0099    | .0501       | 7.93      | 3.5625        | .0044    | .26              | 20,500                         |
| September, . | 96,200                                                              | 63                   | 69        | 2m.                                                                   | 0                                       | None.       | .17    | .0085    | .0296       | 7.92      | 3.0730        | .0059    | .26              | 23,280                         |
| October, .   | 120,000                                                             | 56                   | 60        | 9m.                                                                   | 0                                       | V. sl.      | .21    | .0270    | .0363       | 7.94      | 2.5800        | .0015    | .30              | 48,500                         |
| November, .  | 120,000                                                             | 46                   | 50        | 15m.                                                                  | 3                                       | V. sl.      | .39    | .4132    | .0796       | 7.47      | 2.1175        | .0075    | .52              | 139,500                        |
| December, .  | 103,800                                                             | 47                   | 40        | 1h. 25m.                                                              | 6                                       | Dec.        | .51    | 1.2417   | .1307       | 6.64      | 1.4200        | .1307    | .84              | 92,000                         |

Sewage applied, 600 gallons, 6 times a week, from January 1 to July 8; 150 gallons, 12 times a week, from July 10 to August 31; 200 gallons, 12 times a week, September 1 to 16; 300 gallons, 12 times a week, September 18 to December 1; 600 gallons, 6 times a week, December 2 to 23; 300 gallons, 6 times a week, to December 31. Experiments interrupted by high water, May 5 to 8. May 5, 4 inches dirty sand removed from surface. May 11, 9 inches of new sand put on surface. December 2, 6 inches of sand taken off; next 6 inches turned over, upper 6 inches replaced and mixed with sand below. Air drawn through sand 15 minutes daily, from March 6 to 17; 12 hours daily, March 18 to April 15; 6 hours daily, May 11 to July 10; 3 hours daily, July 31 to September 1. Surface raked about 1 inch deep each week. During the winter months snow was removed 17 times (total depth, 62 inches); ice removed 11 times (total depth, 7.5 inches).

**FILTER No. 2.**

This filter of fine sand was badly clogged at the surface at the beginning of 1893, and although protected by a canvas cover and continuing to give an effluent of excellent quality it could filter but a very small amount of sewage. During January and February the sewage repeatedly froze to the sand and the ice was removed with a pick. The ammonias in the effluent were very low, but nitrification gradually decreased and there was a considerable storage of organic matter in the sand. On March 4 two circular trenches two feet deep and one foot wide, one and a half and five feet, respectively, from the edge of the filter, were constructed. These trenches were filled with No. 9 sand, as is described on page 417, and covered with boards until April 1. The applied sewage equivalent to 40,000 gal-



lons per acre daily for six days in a week disappeared promptly. The ammonias and the nitrates steadily increased until May, after which the ammonias steadily decreased and the nitrates remained high during the entire summer, indicating a removal of much organic matter from the sand. The grass and weeds which grew luxuriantly around the edges of the trenches were cut on July 20 and August 31. The dose was increased September 1 to 60,000 gallons per acre, and the filter continued to do excellent work until the latter part of October, when the trenches began to clog and the increasing free ammonia in the effluent indicated that the ventilation was imperfect. The upper two inches of discolored and partially clogged material were removed from each trench on October 30 and replaced with new sand. This did not restore the efficiency of the filter, owing to a clogging at the bottom of the trenches, which was remedied on December 2 by putting in several layers of mixed coarse and fine sand, as is described on page 417. On December 4 the trenches were covered with boards. This treatment restored the quantitative efficiency of the filter, and the quality of the effluent steadily improved.

*Effluent from Filter No. 2.*

[Parts per 100,000.]

| 1893.        | Quantity<br>Applied<br><br>Gallons<br>per Acre<br>Daily<br>for Six<br>Days in<br>a Week. | TEMPERA-<br>TURE.<br>DEG. F. |           | Length of<br>Time<br>Sewage<br>Remained<br>on<br>Surface.<br><br>Hours and<br>Minutes. | Average<br>Depth<br>of<br>Frost.<br><br>Inches. | APPEAR-<br>ANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Bacteria per Cubic<br>Centimeter. |
|--------------|------------------------------------------------------------------------------------------|------------------------------|-----------|----------------------------------------------------------------------------------------|-------------------------------------------------|------------------|--------|----------|-------------|-----------|----------------|-----------|------------------|-----------------------------------|
|              |                                                                                          | Sewage.                      | Effluent. |                                                                                        |                                                 | Turbidity.       | Color. | Free.    | Albuminoid. |           | Nitrates.      | Nitrites. |                  |                                   |
|              |                                                                                          |                              |           |                                                                                        |                                                 |                  |        |          |             |           |                |           |                  |                                   |
| January, .   | 6,200                                                                                    | 45                           | 35        | 24h.                                                                                   | 9                                               | None.            | .08    | .0030    | .0081       | 5.98      | 1.0350         | .0003     | .12              | 1                                 |
| February, .  | 13,400                                                                                   | 44                           | 37        | 24h.                                                                                   | 11                                              | None.            | .10    | .0048    | .0133       | 5.74      | .4225          | .0001     | .16              | 259                               |
| March, .     | 34,000                                                                                   | 44                           | 35½       | 46m.                                                                                   | 1½                                              | V. sl.           | .12    | .2181    | .0315       | 7.33      | .1800          | .0032     | .38              | 14,048                            |
| April, .     | 40,000                                                                                   | 44½                          | 39½       | 6h.                                                                                    | 0                                               | None.            | .11    | .8675    | .0480       | 6.41      | 1.2112         | .0429     | .28              | 8,081                             |
| May, .       | 37,000                                                                                   | 57                           | 50        | 4m.                                                                                    | 0                                               | None.            | .11    | 1.0533   | .0482       | 5.19      | 3.5744         | .0972     | .24              | 343                               |
| June, .      | 40,000                                                                                   | 68                           | 52        | 8m.                                                                                    | 0                                               | None.            | .07    | .1520    | .0241       | 5.52      | 4.3440         | .0013     | .13              | 45                                |
| July, .      | 40,000                                                                                   | 74½                          | 68        | 8m.                                                                                    | 0                                               | None.            | .04    | .0023    | .0129       | 10.14     | 3.5875         | .0002     | .09              | 119                               |
| August, .    | 37,000                                                                                   | 71                           | 71½       | 13m.                                                                                   | 0                                               | None.            | .04    | .0026    | .0116       | 9.36      | 2.8175         | .0000     | .09              | 34                                |
| September, . | 57,600                                                                                   | 63                           | 67        | 12m.                                                                                   | 0                                               | None.            | .03    | .0016    | .0106       | 7.78      | 3.1320         | .0001     | .08              | 65                                |
| October, .   | 60,600                                                                                   | 54                           | 61½       | 28m.                                                                                   | 0                                               | None.            | .03    | .0115    | .0113       | 8.33      | 3.9975         | .0006     | .07              | 16                                |
| November, .  | 60,000                                                                                   | 45                           | 54        | 1h. 43m.                                                                               | 2                                               | None.            | .07    | .2139    | .0181       | 6.52      | 2.8975         | .1767     | .26              | 37                                |
| December, .  | 60,000                                                                                   | 45                           | 42        | 1h. 18m.                                                                               | 1½                                              | None.            | .09    | .8480    | .0424       | 7.01      | 1.6840         | .3600     | .40              | 2,339                             |

Sewage applied twice in January, four times in February; 400 gallons 3 times a week, March 1 to 15; 200 gallons 6 times a week, March 15 to August 31; 300 gallons 6 times a week, September 1 to December 31. Surface protected by canvas cover until March 4. Trenches protected by boards from March 4 to April 1, and from December 4 to 31. Experiments interrupted by high water May 5 to 8. Two trenches dug 2 feet deep and filled to within 3 inches from top with No. 9 sand March 4. October 30, 2 inches of dirty sand removed from trenches and replaced by clean material. December 2, coarse sand and 2½ inches of fine sand removed from trenches and replaced by mixed coarse and fine for 5 inches, and then filled with coarse. Surface of trenches raked 1 inch deep each week. Grass and weeds cut July 20 and August 31. Ice removed January 11, 18, 31 and February 24.

## FILTER No. 3 A.

In January the prescribed dose, equivalent to 60,000 gallons per acre daily for six days in a week, was taken with some difficulty, owing to the accumulation of organic matter at and near the surface. The quality of the effluent was poor and became worse, although the quantitative efficiency was satisfactory in February. In March the ammonias in the effluent began to steadily decrease, but the free ammonia was still very high. Nitrification slowly improved and became very high in June and July, when there was considerable removal of organic matter stored in the sand. The effluent was well purified. Early in August the surface sand became clogged so that the sewage remained on the surface for twenty-four hours. On August 14 the surface was spaded over, corresponding to ploughing, to a depth of six inches, after which the applied sewage disappeared promptly. Ventilation was restored and the quality of the effluent, which had begun to deteriorate, became good again, with the nitrates very high at the end of the month, when the experiment was discontinued.

*Effluent from Filter No. 3 A.*

[Parts per 100,000.]

| 1893.       | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage Remained on Surface.<br>Hours and Minutes. | Average Depth of Frost.<br>Inches. | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|-------------|---------------------------------------------------------------------|-------------------------|-----------|------------------------------------------------------------------|------------------------------------|-------------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|             |                                                                     | Sewage.                 | Effluent. |                                                                  |                                    | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |
| January, .  | 39,200                                                              | 45                      | 37½       | 17h.                                                             | 8                                  | None.       | .17    | 1.0100   | .0990       | 9.02      | .6825       | .0216     | .55              | 2,035                          |
| February, . | 60,000                                                              | 44                      | 36        | 45m.                                                             | 7                                  | None.       | .21    | 2.4600   | .1580       | 6.57      | .1450       | .0227     | .83              | 1,555                          |
| March, .    | 60,000                                                              | 44                      | 37        | 1h.                                                              | 4                                  | V. sl.      | .37    | 2.2875   | .0675       | 5.43      | .2975       | .0029     | .56              | 975                            |
| April, .    | 60,000                                                              | 45                      | 43        | 6m.                                                              | 0                                  | None.       | .24    | 1.2525   | .0600       | 5.48      | 1.1625      | .0033     | .42              | 72                             |
| May, .      | 55,400                                                              | 56                      | 51½       | 1h. 15m.                                                         | 0                                  | None.       | .17    | .4244    | .0422       | 6.18      | 1.7322      | .0038     | .28              | 83                             |
| June, .     | 60,400                                                              | 70                      | 64½       | 54m.                                                             | 0                                  | None.       | .13    | .0833    | .0374       | 8.16      | 3.7411      | .0031     | .23              | 12                             |
| July, .     | 60,000                                                              | 74                      | 71        | 51m.                                                             | 0                                  | None.       | .06    | .0386    | .0308       | 11.06     | 3.8100      | .0005     | .15              | 27                             |
| August, .   | 55,400                                                              | 70½                     | 72½       | 12m.                                                             | 0                                  | None.       | .05    | .0338    | .0203       | 7.81      | 2.9400      | .0006     | .14              | 25                             |

Sewage applied, 300 gallons 6 times a week. Experiments interrupted by high water May 5 to 8, and May 18 and 19. Surface raked about 1 inch deep each week. Air drawn through sand 15 minutes daily March 13 to 17; 12 hours daily March 18 to April 15. August 14, surface spaded 6 inches deep. Snow and ice removed January 5, 6, 7, 10, 12, 14, 16, 17, 20, 24, 25, 30, 31; February 2, 3, 4, 6, 13, 14, 18, 21, 22, 24, 27, and March 1 and 4.

## FILTER No. 4.

This filter of fine river silt with a large trench of coarse sand and covered with canvas was able to filter sewage at the average rate of 40,000 gallons per acre daily for six days in a week until the early part of March. The ammonias in the effluent were very low, but the nitrates decreased steadily and there was a large storage of organic matter in the sand. To remove the clogging the upper 2 inches of coarse sand in the trench were removed on March 6. This did not remedy matters and on March 11 the canvas cover was removed, the coarse sand dug out of the trench and about  $\frac{1}{2}$  inch in depth of clogged fine sand at the junction of the coarse sand of the trench with the fine sand of the filter scraped off; and the coarse sand was replaced after raking the fine sand to a depth of about 1 inch. This treatment did away with clogging until the last of May. During this time the nitrates and ammonias in the effluent increased. The trench failed to take the sewage promptly toward the last of May and on June 2 a new trench was constructed. The average rate was reduced June 2 to 30,000 gallons per acre daily and the quality of the effluent steadily improved until the last of September, when the purification was excellent. The grass and weeds were cut on August 31. Toward the latter part of October the new trench became clogged and it was allowed to rest and the old one used during the rest of the year. The nitrification decreased in December, although the effluent was very free from organic matter. While the effluent contained but a comparatively small amount of albuminoid ammonia throughout the year, it is to be stated that there was a continual storage of organic matter in the sand.

*Effluent from Filter No. 4.*

[Parts per 100,000.]

| 1893.       | Quan-<br>tity<br>Applied.<br><br>Gallons<br>per Acre<br>Daily<br>for Six<br>Days in<br>a Week. | TEMPERA-<br>TURE.<br>DEG. F. |           | Length of<br>Time<br>Sewage<br>Remained<br>on<br>Surface.<br><br>Hours and<br>Minutes. | Aver-<br>age<br>Depth<br>of<br>Frost.<br><br>Inches. | APPEAR-<br>ANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Bacteria per Cubic<br>Centimeter. |
|-------------|------------------------------------------------------------------------------------------------|------------------------------|-----------|----------------------------------------------------------------------------------------|------------------------------------------------------|------------------|--------|----------|-------------|-----------|----------------|-----------|------------------|-----------------------------------|
|             |                                                                                                | Sewage.                      | Effluent. |                                                                                        |                                                      | Turbidity.       | Color. | Free.    | Albuminoid. |           | Nitrates.      | Nitrites. |                  |                                   |
| January, .  | 40,400                                                                                         | 44                           | 40        | 24h.                                                                                   | 1½                                                   | None.            | .13    | .0006    | .0120       | 7.23      | 1.1725         | .0000     | .23              | 2                                 |
| February, . | 36,600                                                                                         | 44                           | 38½       | 24h.                                                                                   | ½                                                    | None.            | .17    | .0007    | .0163       | 3.75      | .7100          | .0001     | .24              | 9                                 |
| March, .    | 32,800                                                                                         | 42                           | 37½       | 24h.                                                                                   | 0                                                    | None.            | .21    | .0401    | .0453       | 4.70      | .2840          | .0001     | .44              | 230                               |
| April, .    | 41,600                                                                                         | 43½                          | 41        | 21h.                                                                                   | 0                                                    | None.            | .32    | .2750    | .0495       | 4.52      | .6350          | .0015     | .50              | 27                                |
| May, .      | 33,000                                                                                         | 57                           | 50½       | 12h.                                                                                   | 0                                                    | None.            | .34    | .2289    | .0449       | 4.52      | .8457          | .0068     | .48              | 22                                |
| June, .     | 28,000                                                                                         | 69                           | 62½       | 1h. 30m.                                                                               | 0                                                    | None.            | .31    | .1882    | .0436       | 7.24      | .8144          | .0060     | .45              | 27                                |
| July, .     | 30,000                                                                                         | 74½                          | 66½       | 27m.                                                                                   | 0                                                    | None.            | .26    | .1475    | .0480       | 7.90      | 1.4050         | .0155     | .46              | 90                                |
| August, .   | 28,800                                                                                         | 69½                          | 70        | 25m.                                                                                   | 0                                                    | None.            | .29    | .1625    | .0395       | 9.01      | 2.0225         | .0074     | .45              | 19                                |
| September,  | 30,000                                                                                         | 63                           | 65½       | 47m.                                                                                   | 0                                                    | None.            | .22    | .0210    | .0290       | 9.23      | 2.1660         | .0032     | .31              | 20                                |
| October, .  | 29,400                                                                                         | 56                           | 62        | 1h. 20m.                                                                               | 0                                                    | None.            | .14    | .0020    | .0149       | 8.20      | 3.1025         | .0002     | .21              | 13                                |
| November,   | 29,200                                                                                         | 45                           | 52½       | 6h.                                                                                    | 0                                                    | None.            | .14    | .0014    | .0134       | 7.27      | 2.7080         | .0001     | .20              | 11                                |
| December,   | 28,600                                                                                         | 45                           | 44        | 18h.                                                                                   | 1                                                    | None.            | .13    | .0019    | .0191       | 5.79      | 1.5775         | .0002     | .21              | 42                                |

Sewage applied, 400 gallons, 3 times a week until May 12; 200 gallons, 6 times a week, May 13 to June 1; 300 gallons, 3 times a week, June 2 to December 22; 150 gallons, 6 times a week, December 22 to 31. Surface protected by canvas cover till March 11; tank covered with boards, December 4. Experiments interrupted by high water, May 5 to 8 and May 18 and 19. Surface of trench raked about 1 inch deep each week. May 6, 3 to 4 inches of turf removed from surface outside of trench. July 31, entire surface raked over. March 6, 2 inches of dirty sand removed from trench. March 11, coarse sand taken out and replaced after scraping ½ inch from fine sand. June 2, a new trench dug 1 foot inside of old trench, 1 foot wide and 2 feet deep, and filled with coarse sand. New trench used June 2 to October 30. August 31, grass and weeds on surface cut.

**FILTER No. 5 A.**

This filter of fine gravel stones without sand received sewage in January and February in single doses equivalent to 120,000 gallons per acre daily for six days in a week. The surface was unprotected from the weather and with a few exceptions the sewage disappeared promptly. The nitrification was incomplete and the ammonias in the effluent were very high. This was probably owing to a certain extent to the passage of the sewage through the portion of the filter near the point of application and where there was the least frost. In March the quality of the effluent improved, owing in part to the fact that the sewage was applied in three doses daily, and partly to increased ventilation by aspiration. In April, without aspiration, the effluent continued to improve in quality, and in May there was a removal of organic matter from the sand. The filter became clogged

in the early part of June, at a point just below that reached in the weekly raking, to a depth of 1 inch. This was remedied by raking to a depth of 2 inches. The purification was very good for this material in July and a part of August; but sub-surface clogging appeared again in September, and the surface was spaded over, 6 inches deep, corresponding to ploughing, on September 15. On October 30 the rate was increased to 160,000 gallons per acre daily, applied in eight doses daily for six days in a week, and there was no marked deterioration in the quality of the effluent until the last of November, when the filter became clogged again beneath the surface. Two inches of discolored and partially clogged gravel were removed on December 2, and the surface spaded over, 6 inches deep. In December the applied sewage, equivalent to 120,000 gallons per acre, was taken readily, but the nitrification was incomplete and the ammonias in the effluent were very high during the maximum flow.

*Effluent from Filter No. 5 A.*

[Parts per 100,000.]

| 1893.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage Remained on Surface.<br>Hours and Minutes. | Average Depth of Frost.<br>Inches. | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|------------------------------------------------------------------|------------------------------------|-------------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|              |                                                                     | Sewage.                 | Effluent. |                                                                  |                                    | Turbidity.  | Color. | Fres.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |
| January, .   | 115,400                                                             | 43                      | 36        | 1h.                                                              | 9                                  | Dec. .67    | 1.7050 | .2285    | 6.01        | .5675     | .0073       | 1.45      | 387,500          |                                |
| February, .  | 110,000                                                             | 42                      | 36        | 1h. 27m.                                                         | 7                                  | Dec. .46    | 1.3825 | .2570    | 8.31        | .8050     | .0190       | 1.47      | 458,750          |                                |
| March, .     | 120,000                                                             | 40                      | 37½       | 1h.                                                              | 5                                  | V. sl. .28  | .6325  | .1330    | 5.29        | 1.5450    | .0163       | .78       | 419,875          |                                |
| April, .     | 120,000                                                             | 45                      | 45        | 50m.                                                             | 0                                  | V. sl. .30  | .3450  | .1127    | 6.07        | 1.8112    | .0115       | .61       | 150,000          |                                |
| May, .       | 102,200                                                             | 54                      | 54½       | -                                                                | 0                                  | V. sl. .18  | .0371  | .0549    | 5.92        | 2.7600    | .0026       | .26       | 46,750           |                                |
| June, .      | 120,000                                                             | 67                      | 67        | -                                                                | 0                                  | V. sl. .57  | .3071  | .0762    | 9.82        | 1.5033    | .0030       | .47       | 60,500           |                                |
| July, .      | 106,200                                                             | 72                      | 73        | -                                                                | 0                                  | V. sl. .24  | .0115  | .0550    | 9.20        | 1.9950    | .0063       | .26       | 43,750           |                                |
| August, .    | 112,600                                                             | 69½                     | 73        | 13m.                                                             | 0                                  | V. sl. .22  | .0445  | .1040    | 10.69       | 2.3500    | .0057       | .45       | 42,000           |                                |
| September, . | 120,000                                                             | 66                      | 68        | 27m.                                                             | 0                                  | Dec. .52    | .3376  | .0691    | 7.90        | 2.0000    | .0244       | .58       | 107,600          |                                |
| October, .   | 123,000                                                             | 56                      | 60½       | 21m.                                                             | 0                                  | Dec. .29    | .1234  | .0648    | 7.68        | 2.5400    | .0045       | .35       | 388,750          |                                |
| November, .  | 160,000                                                             | 45                      | 49        | 40m.                                                             | 0                                  | Dec. .26    | .3325  | .0770    | 7.55        | 2.5425    | .0070       | .39       | 122,250          |                                |
| December, .  | 120,800                                                             | 42                      | 40        | 25m.                                                             | 7                                  | Dec. .76    | 1.7533 | .2867    | 6.35        | 1.4240    | .0520       | 1.57      | 341,500          |                                |

Sewage applied, 600 gallons, 6 times a week until March 6; 200 gallons, 18 times a week, March 7 to October 28; 100 gallons, 48 times a week, October 30 to December 2; 600 gallons, 6 times a week, December 2 to 11; 300 gallons, 12 times a week, December 12 to 14; 600 gallons, 6 times a week, December 15 to 22; 300 gallons, 12 times a week, December 23 to 31. Experiments interrupted by high water, May 5 to 8 and May 18 and 19. Surface raked 1 inch deep each week. June 12, surface raked 2 inches deep. Surface spaded 6 inches deep September 15 and December 2. Two inches dirty gravel removed from surface December 2. Air drawn through sand fifteen minutes daily, March 6 to 18; two hours, three times daily, May 8 to September 1. Snow removed during the winter months 23 times (70 inches total depth); ice removed 9 times (2.9 inches total depth).

## FILTER No. 6.

This filter, 44 inches in depth of mixed coarse and fine sand and unprotected from the weather, received sewage at the beginning of 1893 at the rate of 70,000 gallons per acre daily for six days in a week. Owing to a storage of organic matter in the surface sand the sewage on very cold days froze to the sand, and it was necessary to omit some doses in January and to remove the ice in places with a pick and shovel in order that the filter might be kept in action. Nitrification was very incomplete in January and the ammonias in the effluent were high. The quantitative efficiency was satisfactory in February, but the effluent deteriorated in quality, owing, in part, to the fact that the oxidation and nitrification functions were thrown out of adjustment by the unfavorable conditions of the preceding weeks, but chiefly to the passage of the sewage through holes in the frost. In March and April the filter steadily improved, while from May to August, inclusive, the effluent was very well purified and moreover there was a removal of a large amount of organic matter which had been stored in the sand. On July 11 the quantity of sewage applied to the filter was increased to 90,000 gallons per acre daily. Surface clogging appeared early in September, and on September 25 the upper 2 inches of discolored and partially clogged sand were removed and replaced with fresh material. The filter did good work again until the last of November, when a clogging occurred at the junction of the old and new sand, as is described on pages 413 and 414. This was remedied on December 2 by spading the surface to a depth of 6 inches. A canvas cover was put on December 4. The purification was quite incomplete during the first half of December, but there was a gradual improvement during the last half of the month.

*Effluent from Filter No. 6.*

[Parts per 100,000.]

| 1893.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage Remained on Surface.<br>Hours and Minutes. | Average Depth of Frost.<br>Inches. | APPEARANCE |        | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|------------------------------------------------------------------|------------------------------------|------------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|              |                                                                     | Sewage.                 | Effluent. |                                                                  |                                    | Turbidity. | Color. | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |
| January, .   | 38,000                                                              | 45                      | 38½       | 24m.                                                             | 9                                  | V. sl.     | .29    | 1.1350   | .0825       | 8.40      | .3325       | .0230     | .74              | 17,275                         |
| February, .  | 67,000                                                              | 44                      | 34½       | 1h. 13m.                                                         | 7                                  | V. sl.     | .39    | 1.7750   | .1775       | 5.86      | .1775       | .0241     | .89              | 50,925                         |
| March, .     | 70,000                                                              | 42                      | 38        | 50m.                                                             | 6                                  | V. sl.     | .24    | 1.6925   | .1040       | 4.92      | 1.2962      | .0461     | .53              | 13,129                         |
| April, .     | 70,000                                                              | 44                      | 44½       | 6m.                                                              | 0                                  | V. sl.     | .19    | .3562    | .0567       | 5.22      | 2.8187      | .1533     | .45              | 5,145                          |
| May, .       | 59,600                                                              | 54                      | 53        | 3m.                                                              | 0                                  | None.      | .14    | .0117    | .0384       | 6.12      | 3.6090      | .0005     | .24              | 4,948                          |
| June, .      | 70,000                                                              | 67                      | 65½       | 10m.                                                             | 0                                  | None.      | .13    | .0066    | .0350       | 10.26     | 3.9700      | .0002     | .21              | 2,775                          |
| July, .      | 75,800                                                              | 72                      | 72½       | 5m.                                                              | 0                                  | None.      | .08    | .0043    | .0857       | 9.99      | 2.8833      | .0181     | .19              | 10,500                         |
| August, .    | 85,600                                                              | 70½                     | 73        | 14m.                                                             | 0                                  | V. sl.     | .11    | .0246    | .0316       | 9.52      | 2.3125      | .0406     | .20              | 10,640                         |
| September, . | 86,600                                                              | 64                      | 68        | 4h. 30m.                                                         | 0                                  | None.      | .15    | .0955    | .0362       | 7.33      | 1.4100      | .0844     | .27              | 3,732                          |
| October, .   | 90,000                                                              | 57                      | 61        | 36m.                                                             | 0                                  | None.      | .10    | .0555    | .0234       | 8.10      | 3.6825      | .0113     | .18              | 3,765                          |
| November, .  | 86,600                                                              | 44½                     | 47        | 1h.                                                              | 0                                  | V. sl.     | .14    | .0477    | .0284       | 6.10      | 2.5140      | .0741     | .27              | 5,802                          |
| December, .  | 77,600                                                              | 43                      | 40        | 12m.                                                             | 1                                  | V. sl.     | .27    | .5890    | .0820       | 6.79      | 1.2720      | .7200     | .89              | 12,840                         |

Sewage applied, 350 gallons, 6 times a week, until July 10; 450 gallons, 6 times a week, July 11 to December 21; 250 gallons, 6 times a week, December 22 to 31. Experiments interrupted by high water May 5 to 8 and May 18 to 20. Surface raked about 1 inch deep each week. September 25, about 2 inches of dirty sand scraped off and replaced by new material. December 2, surface spaded 6 inches deep. Canvas cover put on December 4. Snow removed during the winter months 17 times (63 inches total depth); ice removed 10 times (14.5 inches total depth).

**FILTER NO. 7.***Sub-surface Application of Sewage.*

This filter contains 44 inches of mixed coarse and fine sand like that in No. 6, above which are 10 inches of loam and 6 inches of soil. The sewage is applied in a circular pipe 6 inches in diameter and 18 inches below the surface, with open joints every 2 feet. At the beginning of the year the inlet to this pipe was trapped. After cleaning and relaying this pipe in October, 1892, the sewage was applied without difficulty during the winter months at the rate of 40,000 gallons per acre daily for six days in a week. The nitrification was very incomplete and the effluent contained very high free ammonia. It was thought that the ventilation was interfered with by the rain and melted snow which accumulated upon and at times froze to the surface. On March 15 the quantity of sewage was reduced to 20,000 gallons, but nitrification disappeared entirely

and a reducing action set in, showing that the filter was overdosed. The application of sewage was stopped on April 17 and the sub-surface pipe dug up April 26. In places the accumulated sludge more than half filled the pipe. Analyses showed that this sludge was equivalent to 75 per cent. of the insoluble albuminoid ammonia applied since the pipe was last cleaned. The pipe was relaid without the trap on July 8 and sewage applied at the rate of 40,000 gallons per acre daily for six days in a week. The pipe gradually clogged and the full dose could not be applied after December 1. The nitrification was very high in July, indicating a removal of stored organic matter, but became incomplete in August. Ventilation was increased by aspiration after September 1 and the quality of the effluent improved and remained very satisfactory throughout the year.

For a summary of the information obtained from the experiments upon the sub-surface application of sewage see page 425.

*Effluent from Filter No. 7.*

[Parts per 100,000.]

| 1893.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|-------------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|              |                                                                     | Sewage.                 | Effluent. | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrates.   | Nitrates. |                  |                                |
| January, .   | 37,000                                                              | 39½                     | 39        | Decided.    | 2.25   | 1.4650   | .0655       | 7.09      | .1375       | .0135     | .66              | 2,702                          |
| February, .  | 40,000                                                              | 40                      | 36½       | Slight.     | .57    | 1.9550   | .0750       | 7.10      | .2000       | .0171     | .64              | 2,860                          |
| March, .     | 28,800                                                              | 39                      | 36        | V. slight.  | .59    | 2.2433   | .0870       | 5.26      | .2450       | .0127     | .57              | 2,342                          |
| April, .     | 20,000                                                              | 43                      | 40        | Decided.    | .90    | 2.7467   | .1233       | 4.89      | .0183       | .0015     | 1.68             | 6,633                          |
| May, .       | 0                                                                   | -                       | -         | -           | -      | -        | -           | -         | -           | -         | -                | -                              |
| June, .      | 0                                                                   | -                       | -         | -           | -      | -        | -           | -         | -           | -         | -                | -                              |
| July, .      | 35,800                                                              | 72                      | 69        | None.       | .07    | .2300    | .0493       | 7.88      | 7.2933      | .1167     | .81              | 1,100                          |
| August, .    | 37,000                                                              | 71                      | 70½       | Slight.     | 1.11   | .2725    | .0500       | 8.95      | 1.0475      | .0600     | .58              | 735                            |
| September, . | 40,000                                                              | 64                      | 67½       | Slight.     | .86    | .7400    | .0704       | 7.13      | 1.4360      | .0272     | .46              | 1,066                          |
| October, .   | 38,400                                                              | 56½                     | 60        | None.       | .31    | .1347    | .0244       | 6.99      | 2.6050      | .0020     | .14              | 490                            |
| November, .  | 35,200                                                              | 44                      | 50½       | None.       | .07    | .0073    | .0120       | 6.80      | 3.2450      | .0001     | .10              | 255                            |
| December, .  | 7,400                                                               | 39                      | 42        | None.       | .07    | .0192    | .0148       | 6.04      | 2.7340      | .0018     | .13              | 83                             |

Sewage applied, 200 gallons, 6 times a week till March 10; 100 gallons, 6 times a week, March 11 to April 15. None applied April 17 to July 8; 300 gallons, 6 times a week, July 10 to Nov. 20, after which the quantity which could be applied decreased to less than 200 gallons a week. April 26, drain pipe removed and cleaned, replaced without trap at inlet, July 8. Air drawn through filter twelve hours each day, September 1 to October 20. Air drawn constantly through the filter from October 28 to November 17, and from December 2 to December 23.



## FILTER No. 9 A.

This filter was protected from the weather by a canvas cover and took sewage without difficulty at the rate of 120,000 gallons per acre daily for six days in a week. The surface was not raked, but scraped when necessary, to relieve clogging. The quality of the effluent deteriorated during January, but began to steadily improve in the latter part of February. On March 6 the canvas was removed and the surface scraped. During April, May and June the effluent was very well purified and there was a removal of organic matter stored in the sand. The purification remained satisfactory until November, when sub-surface clogging appeared. The results obtained upon this filter which are presented below are discussed on page 414.

*Effluent from Filter No. 9 A.*

[Parts per 100,000.]

| 1893.        | Quan-<br>tity<br>Applied.<br><br>Gallons<br>per Acre<br>Daily<br>for Six<br>Days in<br>a Week. | TEMPER-<br>TURE.<br>DEG. F. |           | Length of<br>Time<br>Sewage<br>Remained<br>on<br>Surface.<br><br>Hours and<br>Minutes. | Aver-<br>age<br>Depth<br>of<br>Frost.<br><br>Inches. | APPEAR-<br>ANCE. |        | AMMONIA. |             |           | NITROGEN<br>AS |           | Oxygen Consumed. | Bacteria per Cubic<br>Centimeter. |
|--------------|------------------------------------------------------------------------------------------------|-----------------------------|-----------|----------------------------------------------------------------------------------------|------------------------------------------------------|------------------|--------|----------|-------------|-----------|----------------|-----------|------------------|-----------------------------------|
|              |                                                                                                | Sewage.                     | Effluent. |                                                                                        |                                                      | Turbidity.       | Color. | Free.    | Albuminoid. | Chlorine. | Nitrates.      | Nitrites. |                  |                                   |
|              |                                                                                                |                             |           |                                                                                        |                                                      |                  |        |          |             |           |                |           |                  |                                   |
| January, .   | 120,000                                                                                        | 46½                         | 36½       | 3h.                                                                                    | 3                                                    | V. sl.           | .36    | 1.5400   | .1215       | 9.76      | .3350          | .0044     | .65              | 39,600                            |
| February, .  | 120,000                                                                                        | 44                          | 36        | 6h. 30m.                                                                               | 3                                                    | V. sl.           | .40    | 1.4650   | .1300       | 5.98      | .4975          | .0115     | .79              | 73,750                            |
| March, .     | 120,000                                                                                        | 42                          | 38        | 3h.                                                                                    | ½                                                    | None.            | .10    | .4135    | .0419       | 5.74      | 1.4733         | .0033     | .29              | 8,767                             |
| April, .     | 120,000                                                                                        | 45                          | 44½       | -                                                                                      | 0                                                    | None.            | .09    | .0078    | .0257       | 6.07      | 2.5425         | .0001     | .22              | 3,375                             |
| May, .       | 97,000                                                                                         | 53                          | 54        | 40m.                                                                                   | 0                                                    | None.            | .09    | .0060    | .0199       | 5.85      | 3.2775         | .0004     | .19              | 685                               |
| June, .      | 120,000                                                                                        | 66                          | 67        | 53m.                                                                                   | 0                                                    | None.            | .10    | .0228    | .0204       | 9.98      | 3.5240         | .0000     | .19              | 904                               |
| July, .      | 113,000                                                                                        | 71                          | 72        | 45m.                                                                                   | 0                                                    | None.            | .12    | .0263    | .0302       | 8.34      | 2.9433         | .0009     | .18              | 3,750                             |
| August, .    | 106,600                                                                                        | 70                          | 72        | 13h.                                                                                   | 0                                                    | None.            | .06    | .0048    | .0199       | 8.45      | 2.5050         | .0001     | .16              | 547                               |
| September, . | 110,800                                                                                        | 63                          | 67½       | 6h. 30m.                                                                               | 0                                                    | None.            | .19    | .1232    | .0405       | 7.71      | 2.2260         | .0078     | .27              | 1,677                             |
| October, .   | 114,400                                                                                        | 56                          | 60        | 10h.                                                                                   | 0                                                    | None.            | .11    | .0630    | .0256       | 8.00      | 2.8575         | .0009     | .18              | 2,387                             |
| November, .  | 101,000                                                                                        | 45                          | 48        | 16h. 30m.                                                                              | 0                                                    | Slight           | 1.00   | 2.5775   | .1180       | 8.25      | .3500          | .0083     | 1.04             | 9,175                             |
| December, .  | 97,000                                                                                         | 45½                         | 38        | 8h. 15m.                                                                               | 6                                                    | Dec.             | .50    | 2.4433   | .1240       | 6.07      | .9300          | .0190     | .60              | 15,757                            |

Sewage applied, 600 gallons, 6 times a week until December 22, when 300 gallons began to be applied 6 times a week. Surface protected by canvas cover till March 7. Dirty sand scraped from surface March 7, March 14, April 24, July 31, September 1, September 23, October 21, November 6, 16, 18, 20, 21, 22. Filter restored to original depth with clean sand March 14, September 25. The sand removed November 16 to 22 with ½ inch of new sand replaced December 2. Experiments interrupted by high water May 18 to 20. Weeds cut July 13, and pulled up July 31.

## FILTER NO. 11 A.

This filter contains 5 feet of mixed coarse and fine sand which had become clogged and had been removed from the surface of Filter No. 6. Sewage was applied at the rate of 60,000 gallons per acre daily for six days in a week. The effluent was well purified during the winter but began to deteriorate the later part of March, and nitrification decreased steadily. This was caused by incomplete ventilation as the scum at the surface was too thick to dry and crack between doses. Aspiration was tried in July and gave some relief, but to insure permanent improvement the upper 3 inches were removed on August 16, and aspiration tried until September 22. The effluent was very well purified in September and showed a removal of organic matter stored in the sand. The quality of the effluent remained satisfactory through the rest of the year in the absence of aspiration.

For a discussion of this experiment see page 426.

*Effluent from Filter No. 11 A.*

[Parts per 100,000.]

| 1893.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage Remained on Surface.<br>Hours and Minutes. | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS |          | Oxygen Consumed | Bacteria per Cubic Centimeter. |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|------------------------------------------------------------------|-------------|--------|----------|-------------|-----------|-------------|----------|-----------------|--------------------------------|
|              |                                                                     | Sewage.                 | Effluent. |                                                                  | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrate.    | Nitrite. |                 |                                |
|              |                                                                     |                         |           |                                                                  |             |        |          |             |           |             |          |                 |                                |
| January, .   | 60,000                                                              | 48                      | 41½       | 7m.                                                              | V. slight.  | .29    | .0233    | .0580       | 8.13      | 1.8550      | .0031    | .39             | 78,500                         |
| February, .  | 60,000                                                              | 45½                     | 42½       | 6m.                                                              | V. slight.  | .30    | .0396    | .0670       | 6.04      | 1.9950      | .0032    | .40             | 116,000                        |
| March, . .   | 60,000                                                              | 43                      | 43½       | 4m.                                                              | V. slight.  | .25    | .0980    | .0650       | 6.68      | 1.9950      | .0008    | .40             | 17,025                         |
| April, . .   | 60,000                                                              | 45                      | 46        | 7m.                                                              | V. slight.  | .31    | .1500    | .0580       | 5.89      | 1.2000      | .0022    | .47             | 44,000                         |
| May, . . .   | 46,600                                                              | 53                      | 52        | -                                                                | V. slight.  | .31    | .1647    | .0793       | 5.97      | 1.2333      | .0016    | .43             | 42,000                         |
| June, . . .  | 60,000                                                              | 66                      | 61        | 5m.                                                              | Slight.     | 1.17   | .3050    | .0910       | 9.82      | .5150       | .0035    | .64             | 43,000                         |
| July, . . .  | 60,000                                                              | 71                      | 68        | 9m.                                                              | Decided.    | 1.31   | .1500    | .0950       | 8.63      | .5450       | .0070    | .65             | 56,500                         |
| August, . .  | 60,000                                                              | 70                      | 70        | 9m.                                                              | Slight.     | .70    | .0960    | .0880       | 9.90      | .7200       | .0019    | 1.16            | 46,000                         |
| September, . | 60,000                                                              | 63                      | 61        | 11m.                                                             | Decided.    | .40    | .0260    | .0620       | 10.76     | 3.1050      | .0021    | .46             | 11,600                         |
| October, . . | 60,000                                                              | 56                      | 56        | 8m.                                                              | Decided.    | .36    | .1107    | .0573       | 8.96      | 2.1800      | .0037    | .35             | 41,067                         |
| November, .  | 60,000                                                              | 45                      | 40½       | 12m.                                                             | Decided.    | .35    | .0430    | .0460       | 9.64      | 2.7200      | .0030    | .33             | 46,500                         |
| December, .  | 60,000                                                              | 41                      | 44        | 16m.                                                             | Decided.    | .29    | .0460    | .0560       | 6.34      | 1.9700      | .0035    | .37             | 53,000                         |

Sewage applied, 3 gallons, 6 times a week. Surface raked 3 inches deep each week. Air drawn through sand from July 10 to 20; eighteen hours a day July 31 to August 31, and continuously September 1 to 22. Experiments interrupted by high water March 16, May 5 to 8 and 18 to 20. August 14, 3 inches removed from surface.

## FILTERS NOS. 12 A, 15 B AND 16 B.

Filter No. 12 A contains 60 inches in depth of fine sand, and has received the effluents of Filters No. 15 B and 16 B which are filled with coarse gravel. An aspirator was attached to No. 15 B on March 18, and to No. 16 B on January 16. The rate of filtration has been very high for each of these filters—equivalent to 480,000 gallons per acre daily for six days in a week, for the last seven months. The surfaces of these gravel filters were not disturbed until July, 1893, about a year after they were first put in operation. They were raked 3 inches deep once a week after September 1, and daily after October 26. The quality of the effluent was found by series of analyses to be closely dependent upon the current of air drawn through the gravel. Toward the end of the year it was found that the ventilation was less complete than usual, owing to a leak around the outlet pipe. This doubtless explains, to a great extent, the deterioration in the quality of the effluent and also the clogging of the gravel, which necessitated raking on several occasions to a depth of 6 inches.

The effluents of these gravel filters were uniformly well purified by No. 12 A, when operated at a rate of 960,000 gallons per acre daily for six days in a week. Since March 24 the surface has been scraped when necessary to relieve clogging, and has not been raked. It was scraped on an average once in five days, and the average depth removed was 0.24 inch. The removed sand was washed and replaced. To do away with sub-surface clogging the filter was raked to a depth of 6 inches on September 27, December 12 and 27. The deterioration in the quality of the effluents of Filters No. 15 B and 16 B in December, began to make itself apparent toward the end of the year, in the operation of this filter.

These results are discussed on page 422.

*Effluent from Filter No. 12 A.*

[Parts per 100,000.]

| 1893.        | Quantity<br>Applied.<br><br>Gallons<br>per Acre<br>Daily<br>for Six<br>Days in a<br>Week. | TEMPERA-<br>TURE. |           | Length of<br>Time<br>Sewage<br>Remained<br>on<br>Surface.<br><br>Hours and<br>Minutes. | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed | Bacteria per Cubic<br>Centimeter. |
|--------------|-------------------------------------------------------------------------------------------|-------------------|-----------|----------------------------------------------------------------------------------------|-------------|--------|----------|-------------|-----------|----------------|-----------|-----------------|-----------------------------------|
|              |                                                                                           | DEG. F.           |           |                                                                                        | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrates.      | Nitrites. |                 |                                   |
|              |                                                                                           | Sewage.           | Effluent. |                                                                                        |             |        |          |             |           |                |           |                 |                                   |
| January, .   | 480,000                                                                                   | 42                | 45        | 26m.                                                                                   | None.       | .14    | .0119    | .0234       | 6.10      | 1.4850         | .0001     | .21             | 6,622                             |
| February, .  | 542,000                                                                                   | 43                | 46        | 35m.                                                                                   | None.       | .12    | .0013    | .0261       | 5.47      | 1.4425         | .0000     | .21             | 5,919                             |
| March, .     | 606,000                                                                                   | 44                | 46        | 33m.                                                                                   | None.       | .12    | .0130    | .0338       | 6.48      | 1.6550         | .0003     | .29             | 1,125                             |
| April, .     | 720,000                                                                                   | 47                | 50½       | 1h. 20m.                                                                               | V. slight.  | .22    | .0067    | .0470       | 6.61      | 1.7325         | .0002     | .30             | 9,026                             |
| May, .       | 658,000                                                                                   | 54                | 54        | —                                                                                      | None.       | .22    | .0033    | .0405       | 5.81      | 1.8775         | .0003     | .30             | 900                               |
| June, .      | 1,072,000                                                                                 | 63                | 63        | 37m.                                                                                   | None.       | .22    | .0037    | .0254       | 9.41      | 1.6900         | .0000     | .28             | 346                               |
| July, .      | 960,000                                                                                   | 70                | 68        | 1h. 14m.                                                                               | None.       | .19    | .0038    | .0292       | 8.12      | 1.5650         | .0002     | .28             | 121                               |
| August, .    | 960,000                                                                                   | 68                | 68½       | 1h. 24m.                                                                               | None.       | .15    | .0035    | .0267       | 7.72      | 1.5180         | .0000     | .25             | 76                                |
| September, . | 960,000                                                                                   | 60                | 60½       | 1h. 12m.                                                                               | None.       | .13    | .0044    | .0205       | 9.90      | 1.3500         | .0001     | .22             | 347                               |
| October, .   | 960,000                                                                                   | 56                | 55½       | 1h. 30m.                                                                               | None.       | .12    | .0027    | .0211       | 7.76      | 1.3750         | .0001     | .21             | 129                               |
| November, .  | 960,000                                                                                   | 48                | 50½       | 1h. 30m.                                                                               | None.       | .17    | .0049    | .0191       | 13.92     | 1.2975         | .0002     | .24             | 136                               |
| December, .  | 960,000                                                                                   | 44                | 46        | 2h. 10m.                                                                               | None.       | .18    | .0080    | .0255       | 6.06      | 1.2820         | .0020     | .27             | 394                               |

Effluent of Filters Nos. 15 and 16 applied 6 days a week, as follows: 24 gallons till February 12; 30 gallons, February 13 to March 17; 36 gallons, March 18 to May 13; 48 gallons, May 15 to June 10; 60 gallons, June 12 to 25; 48 gallons, June 26 to December 31. Experiments interrupted by high water March 15 to 17, May 4 to 9, May 18 to 21. Surface raked to a depth of about 3 inches once a week until March 24. Surface scraped and sand of previous scraping (after washing) replaced on following dates: March 24, April 11, May 11, 26, June 13, 15, 19, 20, 21, 24, 29, July 4, 5, 11, 14, 18, 20, 29, August 8, 18, 30, September 5, 9, 12, 16, 19, 20, 23, 26, 27, October 26, November 18, December 2, 7, 27. Spaded 6 inches deep September 27, December 10 and 27.

*Effluent from Filter No. 15 B.*

[Parts per 100,000.]

| 1893.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage Remained on Surface.<br>Hours and Minutes. | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|------------------------------------------------------------------|-------------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|              |                                                                     | Sewage.                 | Effluent. |                                                                  | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |
|              |                                                                     |                         |           |                                                                  |             |        |          |             |           |             |           |                  |                                |
| January, .   | 240,000                                                             | 48                      | 42        | -                                                                | Decided.    | .89    | 1.0450   | .1280       | 6.60      | .0450       | .0062     | .85              | 470,000                        |
| February, .  | 240,000                                                             | 44½                     | 43½       | -                                                                | Decided.    | .47    | 1.0375   | .1350       | 5.85      | .0350       | .0004     | .93              | 273,000                        |
| March, .     | 274,000                                                             | 43                      | 44        | 37m.                                                             | Decided.    | .55    | .8675    | .1500       | 6.37      | .5575       | .0005     | 1.05             | 177,750                        |
| April, .     | 360,000                                                             | 46                      | 48        | 11m.                                                             | Decided.    | .46    | .4000    | .1610       | 6.21      | 1.3675      | .0290     | .94              | 330,000                        |
| May, .       | 326,000                                                             | 53                      | 53½       | -                                                                | Slight.     | .41    | .2560    | .1145       | 5.97      | 1.2600      | .0242     | .66              | 103,500                        |
| June, .      | 558,000                                                             | 66                      | 63        | 16m.                                                             | V. slight.  | .39    | .5790    | .1633       | 10.22     | 1.2033      | .0173     | .81              | 117,166                        |
| July, .      | 480,000                                                             | 71                      | 69        | 10m.                                                             | Decided.    | 1.31   | 1.2550   | .2497       | 8.46      | .8122       | .0177     | 1.15             | 421,200                        |
| August, .    | 480,000                                                             | 70                      | 68        | 24m.                                                             | V. slight.  | .54    | .3336    | .0992       | 9.42      | 1.4700      | .0136     | .56              | 70,800                         |
| September, . | 480,000                                                             | 63                      | 60        | 23m.                                                             | Decided.    | .61    | .3600    | .1155       | 12.80     | 1.2825      | .0600     | .63              | 64,050                         |
| October, .   | 480,000                                                             | 56                      | 55½       | 1h. 30m.                                                         | Decided.    | .46    | .4350    | .1240       | 9.56      | 1.5425      | .0275     | .65              | 132,000                        |
| November, .  | 480,000                                                             | 45                      | 48½       | 50m.                                                             | Decided.    | .51    | .5200    | .1010       | 14.09     | 1.0925      | .0362     | .67              | 137,000                        |
| December, .  | 480,000                                                             | 41                      | 45        | 1h.                                                              | Decided.    | .51    | 1.1500   | .1784       | 6.06      | .6440       | .0116     | .97              | 209,200                        |

Sewage applied, 3 gallons 24 times a week, till March 15; 3 gallons 36 times a week, March 18 to May 13; 4 gallons 36 times a week, May 15 to June 10; 5 gallons 36 times a week, June 12 to 25; 4 gallons 36 times a week, June 26 to October 22; 2 gallons 72 times a week, October 23 to December 31. Experiments interrupted by high water March 15 to 17, May 4 to 9, May 18 to 21. Air drawn through gravel from March 18 to July 10, and from July 15 to December 31. Surface raked 3 inches deep 4 times, July 28 to September 1, and each week from September 1 to October 26; 3 inches deep daily, October 26 to November 27, after which surface was raked from 6 to 10 inches deep, as follows: 6 inches deep on November 28, 29, 30, December 1, 2, 11, 15 and 16; 8 inches deep December 3 and 12; 10 inches deep December 8.

*Effluent from Filter No. 16 B.*

[Parts per 100,000.]

| 1893.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage Remained on Surface.<br>Hours and Minutes. | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed | Bacteria per Cubic Centimeter. |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|------------------------------------------------------------------|-------------|--------|----------|-------------|-----------|-------------|-----------|-----------------|--------------------------------|
|              |                                                                     | Sewage.                 | Effluent. |                                                                  | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrates.   | Nitrates. |                 |                                |
| January, .   | 240,000                                                             | 48                      | 41        | -                                                                | Decided.    | .72    | .5750    | .1425       | 7.14      | .9725       | .0869     | .82             | 435,250                        |
| February, .  | 302,000                                                             | 45½                     | 41½       | -                                                                | Decided.    | .40    | .3250    | .1410       | 6.33      | 1.1575      | .1740     | .99             | 244,950                        |
| March, .     | 332,000                                                             | 43                      | 43        | 12m.                                                             | Slight.     | .46    | .5760    | .1356       | 5.82      | 1.1000      | .0074     | .93             | 176,400                        |
| April, .     | 360,000                                                             | 45                      | 46½       | 13m.                                                             | Slight.     | .46    | .3025    | .1655       | 6.58      | 1.0525      | .2659     | 1.03            | 222,500                        |
| May, .       | 332,000                                                             | 53                      | 54        | -                                                                | Slight.     | .42    | .2215    | .1095       | 5.94      | 1.4200      | .0006     | .64             | 113,750                        |
| June, .      | 536,000                                                             | 66                      | 63        | 16m.                                                             | V. slight.  | .36    | .3143    | .1067       | 10.02     | 1.2250      | .0049     | .67             | 94,500                         |
| July, .      | 480,000                                                             | 71                      | 70        | 9m.                                                              | Slight.     | .87    | .7229    | .1797       | 8.30      | 1.5453      | .0089     | .83             | 69,714                         |
| August, .    | 480,000                                                             | 70                      | 68½       | 8m.                                                              | Slight.     | .57    | .4160    | .1484       | 9.23      | 1.0900      | .0682     | .71             | 81,200                         |
| September, . | 480,000                                                             | 63                      | 60        | 13m.                                                             | Decided.    | .86    | .7225    | .1400       | 11.91     | .6300       | .1900     | .79             | 87,800                         |
| October, .   | 480,000                                                             | 56                      | 56        | 45m.                                                             | Decided.    | .51    | .5725    | .1255       | 10.20     | .8425       | .0387     | .63             | 157,250                        |
| November, .  | 480,000                                                             | 45                      | 47        | 4m.                                                              | Decided.    | .57    | .5725    | .2455       | 15.55     | .8700       | .0447     | 1.26            | 277,750                        |
| December, .  | 480,000                                                             | 41                      | 44        | 37m.                                                             | Decided.    | .45    | 1.1780   | .2216       | 5.96      | .5000       | .0142     | .99             | 163,200                        |

Sewage applied, 3 gallons 24 times a week, till February 12; 3 gallons 36 times a week, February 13 to May 14; 4 gallons 36 times a week from May 15 to June 11; 5 gallons 36 times a week, June 12 to 25; 4 gallons 36 times a week, June 26 to October 22; 2 gallons 72 times a week from October 23 to December 31. Experiments interrupted by high water March 15 to 17; May 4 to 9; May 18 to 21; Air drawn through gravel January 16 to December 31. Surface raked 3 inches deep 4 times from July 18 to September 1 and each week from September 1 to October 26; 3 inches deep daily, October 26 to December 31, with the following exceptions: 8 inches deep, December 12, and 6 inches deep, December 30.

## FILTER No. 13.

This filter was used during the winter months for confirmation of experiments to determine the effect of nitrification upon the removal of bacteria by filtration. Beginning March 22 sewage was applied at the rate of 160,000 gallons per acre daily for six days in a week. This was done with a view to obtaining, in conjunction with Filter No. 14, some comparable results upon the removal of dyestuffs from sewage by filters of coarse sand with and without the presence of polarite. These results are summarized on page 427.

*Effluent from Filter No. 13.*

[Parts per 100,000.]

| 1893.        | Quantity Applied.<br><br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage remained on Surface.<br>—<br>Hours and Minutes. | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|-------------------------------------------------------------------------|-------------------------|-----------|-----------------------------------------------------------------------|-------------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|              |                                                                         | Sewage.                 | Effluent. |                                                                       | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |
|              |                                                                         |                         |           |                                                                       |             |        |          |             |           |             |           |                  |                                |
| January, .   | 80,000                                                                  | -                       | 46        | 3m.                                                                   | None.       | .09    | .0009    | .0136       | 0.43      | .0975       | .0000     | .08              | 12,740                         |
| February, .  | 80,000                                                                  | -                       | 45½       | 3m.                                                                   | None.       | .06    | .0006    | .0085       | 0.31      | .1500       | .0000     | .05              | 3,225                          |
| March, .     | 90,000                                                                  | 43                      | 45½       | 3m.                                                                   | V. slight.  | .09    | .0059    | .0385       | 1.67      | .8250       | .0023     | .37              | 9,010                          |
| April, .     | 160,000                                                                 | 45                      | 49        | 8m.                                                                   | V. slight.  | .18    | .0175    | .0807       | 5.20      | 2.4267      | .0079     | .30              | 67,000                         |
| May, .       | 124,400                                                                 | 53                      | 54        | -                                                                     | V. slight.  | .14    | .0052    | .0490       | 6.01      | 3.3260      | .0004     | .23              | 50,600                         |
| June, .      | 160,000                                                                 | 66                      | 64        | 4m.                                                                   | V. slight.  | .15    | .0041    | .0517       | 8.44      | 3.2900      | .0007     | .24              | 54,000                         |
| July, .      | 160,000                                                                 | 71                      | 65        | 4m.                                                                   | V. slight.  | .16    | .0051    | .0488       | 8.21      | 3.8600      | .0008     | .20              | 45,000                         |
| August, .    | 160,000                                                                 | 70                      | 66        | 5m.                                                                   | V. slight.  | .13    | .0045    | .0403       | 7.47      | 2.2167      | .0007     | .22              | 51,667                         |
| September, . | 160,000                                                                 | 63                      | -         | 9m.                                                                   | V. slight.  | -      | .0026    | .0404       | 7.55      | 2.2400      | .0012     | .24              | 22,900                         |

Three gallons effluent from Filter No. 18 A applied, 6 times a week, till March 21. Eight gallons sewage applied, 6 times a week, March 22 to September 27. Forty-four hundredths parts per 100,000 of Scarlet 2R applied in sewage, August 26 to September 7. Sand washed September 9, by applying city water, to remove traces of Scarlet 2R, and 0.33 parts per 100,000 of Patent Blue applied in sewage, September 23-27. Experiment discontinued September 27.

## FILTER No. 13 A.

This filter contains 60 inches in depth of sand of an effective size of 0.19 millimeter, and was constructed on September 27, 1893. It has received the supernatant liquid from sewage which had been allowed to settle four hours. The surface, which has been scraped when necessary to relieve clogging and not raked, was scraped on an average once in six days, and the average depth removed was 0.37 inch. Owing to sub-surface clogging it was necessary to spade over the surface 6 inches deep three times in December. It appeared that the rate of filtration, 480,000 gallons per acre daily for six days in a week, overtaxed the capacity of the filter, which was allowed to rest for two weeks beginning December 23. The results are discussed on page 423.

*Effluent from Filter No. 13 A.*

[Parts per 100,000.]

| 1893.     | Quantily Applied.<br><br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage Remained on Surface.<br><br>Hours and Minutes. | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed | Bacteria per Cubic Centimeter. |
|-----------|-------------------------------------------------------------------------|-------------------------|-----------|----------------------------------------------------------------------|-------------|--------|----------|-------------|-----------|-------------|-----------|-----------------|--------------------------------|
|           |                                                                         | Sewage.                 | Effluent. |                                                                      | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                 |                                |
|           |                                                                         |                         |           |                                                                      |             |        |          |             |           |             |           |                 |                                |
| October,  | 400,000                                                                 | -                       | 56        | 15m.                                                                 | None.       | .08    | 1.6725   | .0650       | 9.33      | .5925       | .1775     | .33             | 3,300                          |
| November, | 480,000                                                                 | -                       | 50        | 1h. 40m.                                                             | None.       | .13    | .8825    | .0405       | 9.46      | 1.4500      | .1450     | .34             | 3,855                          |
| December, | 360,000                                                                 | -                       | 46        | 1h. 50m.                                                             | Slight.     | .28    | 2.6900   | .0670       | 6.28      | .7300       | .0475     | .40             | 28,075                         |

Sewage (settled 4 hours) applied, 6 gallons 18 times a week, September 27 to October 22; 3 gallons 48 times a week, October 23 to December 23, after which none was applied. Surface scraped and sand of previous scraping (after washing) replaced on following dates: October 9, 21, 27, November 1, 7, 13, 17, 24, 28, 30, December 5, 7, 18. Spaded over 6 to 7 inches deep, December 2, 12, 19.

## FILTER No. 14.

This filter is 63 inches deep and contains sand of an effective size of 0.48 millimeter. On January 21, 1893, the upper 6 inches of partially clogged and discolored sand were removed; the next 7 inches were taken out and, after putting in 7 inches in depth of polarite, were used to fill the filter to its original depth. The chief experiment was upon the removal of color from sewage containing dye-stuffs, which is summarized on page 427.

The rate of filtration was 160,000 gallons per acre daily for six days in a week until October 23 when the rate was doubled. The quality of the effluent was uniformly good until the middle of November, when clogging occurred at the surface of the polarite. The filter was allowed to rest from November 16 to December 4, when sewage was again applied at the rate of 160,000 gallons. The effluent was well purified, but clogging began to gradually reappear.

*Effluent from Filter No. 14.*

[Parts per 100,000.]

| 1893.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage Remained on Surface.<br>Hours and Minutes. | APPEARANCE. |              | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|------------------------------------------------------------------|-------------|--------------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|              |                                                                     | Sewage.                 | Effluent. |                                                                  | Turbidity.  | Color.       | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |
| January, .   | 160,000                                                             | 48                      | 48        | 34m.                                                             | V.slight.   | Slight blue. | .0071    | .0363       | 6.44      | 1.7767      | .0006     | .37              | 32,667                         |
| February, .  | 160,000                                                             | 45½                     | 44        | 7m.                                                              | None.       | Slight green | .0029    | .0447       | 6.51      | 2.6025      | .0003     | .33              | 50,125                         |
| March, .     | 160,000                                                             | 43                      | 44        | 6m.                                                              | None.       | Green.       | .0042    | .0347       | 5.23      | 3.0975      | .0000     | .28              | 15,075                         |
| April, .     | 160,000                                                             | 45                      | 47½       | 9m.                                                              | None.       | Green.       | .0044    | .0335       | 5.86      | 3.2850      | .0000     | .26              | 15,250                         |
| May, .       | 124,400                                                             | 53                      | 54        | -                                                                | None.       | Green.       | .0054    | .0329       | 6.20      | 3.6940      | .0000     | .24              | 12,600                         |
| June, .      | 160,000                                                             | 66                      | 63½       | 10m.                                                             | None.       | Green.       | .0063    | .0313       | 8.52      | 4.2325      | .0002     | .26              | 49,333                         |
| July, .      | 160,000                                                             | 71                      | 65        | 6m.                                                              | None.       | Green.       | .0079    | .0433       | 8.38      | 3.7100      | .0016     | .26              | 60,000                         |
| August, .    | 160,000                                                             | 70                      | 65½       | 4m.                                                              | V.slight.   | Slight blue. | .0039    | .0376       | 7.85      | 2.3167      | .0005     | .22              | 71,333                         |
| September, . | 160,000                                                             | 63                      | 58½       | 8m.                                                              | V.slight.   | Slight blue. | .0023    | .0277       | 7.97      | 1.9800      | .0002     | .17              | 55,000                         |
| October, .   | 209,200                                                             | 56                      | 54        | 10m.                                                             | V.slight.   | Slight blue. | .0018    | .0326       | 7.69      | 1.6300      | .0000     | .18              | 45,000                         |
| November, .  | 320,000                                                             | 45                      | 48        | 12h.                                                             | V.slight.   | Slight blue. | .0150    | .0327       | 16.05     | 0.9200      | .0025     | .20              | 23,667                         |
| December, .  | 160,000                                                             | 41                      | 44½       | 2h.                                                              | None.       | .10          | .0025    | .0208       | 5.69      | 2.9500      | .0007     | .17              | 22,500                         |

Sewage applied, 8 gallons 6 times a week, till October 22; 8 gallons 12 times a week, October 23 to November 16; 8 gallons 6 times a week, December 4 to December 31. Color applied in sewage February 13 to March 22 and August 26 to September 28. Experiments interrupted by high water March 15 to 17; May 4 to 9; May 18 to 21. Surface raked 3 inches deep each week.

## FILTER No. 17 A.

This filter of medium fine sand, with four layers of marble dust, received during the entire year sewage to which sulphuric acid equal to 49 parts in 100,000 of actual  $H_2SO_4$  was added. The rate of filtration was 60,000 gallons per acre daily for six days in a week. The free ammonia in the effluent began to increase in November, 1892, and was unusually high during the greater part of 1893. This increase, as well as that of the albuminoid ammonia, was owing to an interruption in ventilation caused by clogging. To remedy this the upper layer of marble dust, about 3 inches below the surface, in July, and later the sand above this layer, were replaced with new materials. It was found that the original layer of marble dust had occasionally been disturbed in the weekly raking and this treatment gave only temporary relief. Clogging again occurred in September, nitrification was very incomplete, and there was present a reducing action, as the sand down to the second layer of marble dust (12 inches) was very black with iron sulphide. A thin layer was scraped from the surface of the second portion of marble dust in October and the old sand replaced. The quality of the effluent steadily improved and in December was excellent.

*Effluent from Filter No. 17 A.*

[Parts per 100,000.]

| 1893.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage Remained on Surface.<br>Hours and Minutes. | APPEARANCE. |        | AMMONIA. |             | NITROGEN AS |           |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|------------------------------------------------------------------|-------------|--------|----------|-------------|-------------|-----------|-----------|------------------|--------------------------------|
|              |                                                                     | Sewage.                 | Effluent. |                                                                  | Turbidity.  | Color. | Free.    | Albuminoid. | Chlorine.   | Nitrates. | Nitrites. |                  |                                |
| January, .   | 60,000                                                              | 48                      | 44        | 3h.                                                              | None.       | .10    | .1320    | .0175       | 9.57        | 2.1700    | .0002     | .51              | 38                             |
| February, .  | 60,000                                                              | 45½                     | 42        | 3h. 40m.                                                         | None.       | .10    | .0812    | .0196       | 8.81        | 1.8250    | .0004     | .26              | 5                              |
| March, .     | 59,000                                                              | 43                      | 43        | 2h. 45m.                                                         | None.       | .08    | .2163    | .0370       | 6.01        | 2.0200    | .0002     | .18              | 0                              |
| April, .     | 60,000                                                              | 45                      | 46        | 6h. 40m.                                                         | None.       | .16    | .1771    | .0254       | 5.93        | 2.4550    | .0003     | .22              | 4                              |
| May, .       | 46,000                                                              | 53                      | 53        | -                                                                | None.       | .13    | .0630    | .0269       | 6.33        | 3.1667    | .0005     | .26              | 45                             |
| June, .      | 60,000                                                              | 66                      | 64½       | 1h.                                                              | None.       | .13    | .4700    | .0390       | 9.04        | 4.3450    | .0028     | .27              | 26                             |
| July, .      | 60,000                                                              | 71                      | 70        | 1h.                                                              | V. slight.  | .17    | .1700    | .0510       | 8.92        | 3.9250    | .0028     | .28              | 920                            |
| August, .    | 60,000                                                              | 70                      | 72        | 45m.                                                             | None.       | .12    | .0140    | .0233       | 12.63       | 2.4750    | .0015     | .26              | 370                            |
| September, . | 60,000                                                              | 63                      | 62½       | 12h.                                                             | V. slight.  | .13    | .2185    | .0310       | 12.73       | 1.0050    | .0043     | .25              | 124                            |
| October, .   | 60,000                                                              | 56                      | 59½       | 12h.                                                             | V. slight.  | .15    | 1.6500   | .0690       | 7.72        | .5200     | .0185     | .36              | 1,670                          |
| November, .  | 60,000                                                              | 45                      | 48½       | 2h. 40m.                                                         | None.       | .13    | .1365    | .0406       | 8.67        | 3.6250    | .0061     | .28              | 815                            |
| December, .  | 60,000                                                              | 41                      | 42        | 2h. 35m.                                                         | None.       | .09    | .0022    | .0149       | 6.52        | 2.4800    | .0008     | .18              | 302                            |

Three gallons of sewage plus sulphuric acid equal to 49 parts per 100,000 applied 6 times a week. Surface raked 3 inches deep each week. Experiments interrupted by high water March 15 to 17, May 4 to 9, May 17 to 21. July 12, upper layer of marble dust replaced by a fresh layer. August 16, upper 3 inches of sand replaced by fresh sand. September 29, upper layer of marble dust disturbed. October 21, marble dust and upper 3 inches of sand removed. October 25, 9 inches of sand removed and second layer of marble dust scraped; sand replaced with 3 inches of clean material.



## FILTER No. 19.

This filter of medium fine sand has received since January 20, 1893, the supernatant liquid from sewage which was allowed to settle for four hours after treatment with alum at the rate of 1,000 pounds per million gallons. The rate of filtration was 120,000 gallons per acre daily for six days in a week up to June 12, after which the rate was increased from time to time until it became 640,000 gallons on and after October 23. From April to August, inclusive, the quality of the effluent was excellent, but the ammonias began to increase in September and continued to do so during the rest of the year. Since October 23 the surface has been scraped to relieve clogging. It has been scraped on an average once in ten days, and the average depth removed was 0.47 inch. On December 2 and 12 the surface was spaded over, 6 inches deep, to relieve clogging. This clogging and the deterioration in the quality of the effluent indicated that this high rate of filtration when long continued overtaxed the capacity of the filter which was allowed to rest for two weeks beginning December 23. See page 422 for a discussion of these results.

*Effluent from Filter No. 19.*

[Parts per 100,000.]

| 1893.        | Quantity Applied.<br><br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time.<br>Sewage Remained on Surface.<br><br>Hours and Minutes. | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|-------------------------------------------------------------------------|-------------------------|-----------|--------------------------------------------------------------------------|-------------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|              |                                                                         | Sewage.                 | Effluent. |                                                                          | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |
|              |                                                                         |                         |           |                                                                          |             |        |          |             |           |             |           |                  |                                |
| January, .   | 74,000                                                                  | -                       | 41½       | 1h.                                                                      | None.       | .37    | .2828    | .0279       | 8.59      | 1.1500      | .0044     | .39              | 51,773                         |
| February, .  | 120,000                                                                 | -                       | 43        | 10m.                                                                     | None.       | .18    | .9900    | .0400       | 7.69      | 1.1600      | .0600     | .33              | 17,262                         |
| March, .     | 110,000                                                                 | -                       | 41        | 11m.                                                                     | None.       | .08    | .1681    | .0255       | 5.25      | 2.0900      | .0440     | .23              | 5,467                          |
| April, .     | 120,000                                                                 | -                       | 45½       | 10m.                                                                     | None.       | .11    | .0066    | .0156       | 5.66      | 2.1700      | .0008     | .18              | 545                            |
| May, .       | 94,000                                                                  | -                       | 53        | -                                                                        | None.       | .11    | .0083    | .0237       | 6.01      | 2.5000      | .0005     | .15              | 495                            |
| June, .      | 146,000                                                                 | -                       | 63        | 12m.                                                                     | V. slight.  | .12    | .0057    | .0200       | 9.95      | 2.1620      | .0002     | .18              | 594                            |
| July, .      | 160,000                                                                 | -                       | 67        | 12m.                                                                     | None.       | .08    | .0082    | .0216       | 8.42      | 3.3900      | .0002     | .18              | 870                            |
| August, .    | 240,000                                                                 | -                       | 68        | 9m.                                                                      | None.       | .08    | .0028    | .0174       | 7.34      | 1.8000      | .0000     | .15              | 217                            |
| September, . | 480,000                                                                 | -                       | 66        | 33m.                                                                     | None.       | .07    | .0609    | .0192       | 6.63      | 2.3550      | .0055     | .15              | 432                            |
| October, .   | 530,000                                                                 | -                       | 56        | 45m.                                                                     | V. slight.  | .13    | .7691    | .0507       | 10.30     | 1.8125      | .0026     | .27              | 3,122                          |
| November, .  | 640,000                                                                 | -                       | 46        | 1h. 40m.                                                                 | V. slight.  | .18    | 1.7200   | .0585       | 10.07     | 1.7625      | .0109     | .30              | 1,545                          |
| December, .  | 492,000                                                                 | -                       | 41½       | 2h.                                                                      | Slight.     | .21    | 2.3800   | .0890       | 6.32      | .8600       | .0033     | .49              | 6,695                          |

Six gallons of chemically clarified sewage applied 6 times a week, till June 11; 8 gallons 6 times a week, June 12 to July 30; 6 gallons 12 times a week, July 31 to August 31; 4 gallons 36 times a week, September 1 to October 22; 4 gallons 48 times a week, October 23 to December 23, after which none was applied. Experiments interrupted by high water March 15 to 17, May 4 to 9, May 18 to 21. Surface raked 3 inches deep each week until October 23, after which surface was scraped and sand of previous scraping (after washing) replaced on following dates: November 3, 13, 18, 22, 23. Spaded, 6 inches deep, December 2, 12. October 6, upper 4 inches removed and replaced with fresh sand.

## FILTER No. 25.

In this filter was buried on December 18, 1889, the carcass of a dog above 5 feet of sand and loam and beneath 6 feet of sand, loam and soil, as was described in the Special Report upon the Purification of Sewage and Water (page 689). Since May 9, 1892, city water has been applied at the rate of 60,000 gallons per acre daily for six days in a week. There was a marked improvement in the chemical quality of the effluent in 1892, but the numbers of bacteria increased. In 1893 there have been no marked changes in the chemical characteristics of the effluent, and while the numbers of bacteria have been quite variable, they have averaged considerably lower than during the latter part of the preceding year. The effluent has been uniformly discolored by iron. The odor and turbidity have been very much less marked than formerly, but are still perceptible.

*Effluent from Filter No. 25.*

[Parts per 100,000.]

|                      | Quantity<br>Applied.<br><br>Gallons per<br>Acre Daily<br>for Six Days<br>in a Week. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen<br>Consumed. | Bacteria per<br>Cubic Centi-<br>meter. |
|----------------------|-------------------------------------------------------------------------------------|----------|-------------|-----------|-------------|-----------|---------------------|----------------------------------------|
|                      |                                                                                     | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                     |                                        |
|                      |                                                                                     |          |             |           |             |           |                     |                                        |
| 1892.                |                                                                                     |          |             |           |             |           |                     |                                        |
| January, . . . . .   | 10,000                                                                              | 4.2500   | .0700       | .25       | .130        | .0180     | .28                 | 0                                      |
| February, . . . . .  | 10,000                                                                              | 3.6500   | .1000       | .30       | .080        | .0080     | .18                 | 0                                      |
| March, . . . . .     | 10,000                                                                              | 2.2000   | .0600       | .25       | .050        | .0080     | .46                 | 0                                      |
| April, . . . . .     | 10,000                                                                              | 3.6000   | .0400       | .30       | .080        | .0150     | .09                 | 0                                      |
| May, . . . . .       | 46,000                                                                              | 2.8000   | .0605       | .23       | .080        | .0055     | .30                 | 6                                      |
| June, . . . . .      | 60,000                                                                              | 1.2333   | .0327       | .16       | .020        | .0067     | .11                 | 4                                      |
| July, . . . . .      | 60,000                                                                              | .8750    | .0310       | .16       | .010        | .0040     | .11                 | 10                                     |
| August, . . . . .    | 60,000                                                                              | .8200    | .0260       | .19       | .010        | .0018     | .13                 | 175,000                                |
| September, . . . . . | 60,000                                                                              | .7000    | .0380       | .35       | .010        | .0000     | .15                 | 23,400                                 |
| October, . . . . .   | 60,000                                                                              | .5300    | .0160       | .22       | .000        | .0004     | .10                 | 20,000                                 |
| November, . . . . .  | 60,000                                                                              | .3400    | .0260       | .29       | .010        | .0004     | .09                 | 25,000                                 |
| December, . . . . .  | 60,000                                                                              | .2700    | .0180       | .24       | .005        | .0010     | .02                 | 40,000                                 |
| 1893.                |                                                                                     |          |             |           |             |           |                     |                                        |
| January, . . . . .   | 60,000                                                                              | .2700    | .0080       | .22       | .010        | .0012     | .15                 | 2,000                                  |
| February, . . . . .  | 60,000                                                                              | .3500    | .0180       | .30       | .015        | .0014     | .26                 | 3,000                                  |
| March, . . . . .     | 58,000                                                                              | .3000    | .0100       | .27       | .022        | .0036     | .09                 | 1,240                                  |
| April, . . . . .     | 60,000                                                                              | .2900    | .0220       | .22       | .019        | .0000     | .26                 | 1,200                                  |
| May, . . . . .       | 40,000                                                                              | .3450    | .0260       | .12       | .021        | .0007     | .16                 | 200                                    |
| June, . . . . .      | 60,000                                                                              | .8800    | .0320       | .19       | .094        | .0020     | .12                 | 2                                      |
| July, . . . . .      | 60,000                                                                              | .3700    | .0260       | .20       | .040        | .0018     | .13                 | 9                                      |
| August, . . . . .    | 60,000                                                                              | .3300    | .0180       | .22       | .008        | .0030     | .17                 | 600                                    |
| September, . . . . . | 60,000                                                                              | .2600    | .0180       | .22       | .009        | .0020     | .08                 | 6                                      |
| October, . . . . .   | 60,000                                                                              | .2200    | .0240       | .23       | .007        | .0030     | .09                 | 2,220                                  |
| November, . . . . .  | 60,000                                                                              | -        | -           | -         | -           | -         | -                   | -                                      |
| December, . . . . .  | 65,000                                                                              | .2500    | .0170       | .20       | .012        | .0045     | .05                 | 675                                    |

Outlet pipe trapped. City water applied in 3 gallon doses once a week until May 9, 1892, and since that time 6 times a week. Experiment interrupted by high water March 15 to 17, May 4 to 9 and May 18 to 22, 1893. Surface scraped July 10, 1893. The applied water froze on the surface several times during the severest winter weather and was removed.

## FILTER No. 30.

This filter contains 30 inches in depth of coarse sand of an effective size of 0.48 millimeter. It has received sewage at a uniform rate of 55,800 gallons per acre daily for six days in a week with satisfactory results. No disturbance of the material, other than the weekly raking, has taken place since the filter was first put in operation, May 31, 1890.

*Effluent from Filter No. 30.*

[Parts per 100,000.]

| 1893.        | Quantity Applied.<br>—<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage Remained on Surface.<br>Hours and Minutes. | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|--------------------------------------------------------------------------|-------------------------|-----------|------------------------------------------------------------------|-------------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|              |                                                                          | Sewage.                 | Effluent. |                                                                  | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |
| January, .   | 55,800                                                                   | 48                      | 40½       | 2m.                                                              | Slight.     | .46    | .0561    | .0590       | 6.16      | 2.0300      | .0022     | .45              | 20,231                         |
| February, .  | 55,800                                                                   | 45½                     | 43½       | 3m.                                                              | V. slight.  | 1.92   | .0265    | .0566       | 6.02      | 2.2100      | .0007     | .46              | 60,500                         |
| March, .     | 55,800                                                                   | 43                      | 40        | 2m.                                                              | V. slight.  | .38    | .0510    | .0549       | 5.35      | 2.6700      | .0007     | .38              | 28,500                         |
| April, .     | 55,800                                                                   | 45                      | 43½       | 2m.                                                              | V. slight.  | .30    | .0560    | .0492       | 6.87      | 2.7150      | .0006     | .35              | 13,500                         |
| May, .       | 47,500                                                                   | 53                      | 54        | -                                                                | V. slight.  | .26    | .0714    | .0602       | 6.13      | 3.0000      | .0019     | .32              | 53,333                         |
| June, .      | 55,800                                                                   | 66                      | 64½       | 1m.                                                              | V. slight.  | .26    | .1440    | .0710       | 12.89     | 4.0650      | .0032     | .38              | 32,000                         |
| July, .      | 55,800                                                                   | 71                      | 70        | 1m.                                                              | V. slight.  | .31    | .1800    | .0940       | 8.67      | 5.0250      | .0100     | .47              | 3,600                          |
| August, .    | 55,800                                                                   | 70                      | 70½       | 1m.                                                              | V. slight.  | .34    | .0670    | .0670       | 8.92      | 2.8050      | .0075     | .33              | 8,000                          |
| September, . | 55,800                                                                   | 63                      | 65½       | 2m.                                                              | Decided.    | .41    | .1060    | .0680       | 11.90     | 2.2050      | .0012     | .38              | 12,900                         |
| October, .   | 55,800                                                                   | 56                      | 56½       | 2m.                                                              | Slight.     | .50    | .1360    | .0450       | 8.19      | 2.6000      | .0045     | .41              | 50,700                         |
| November, .  | 55,800                                                                   | 45                      | 47        | 28m.                                                             | Slight.     | .28    | .0620    | .0480       | 23.60     | 2.1600      | .0020     | .28              | 23,000                         |
| December, .  | 55,800                                                                   | 41                      | 39½       | 10m.                                                             | Decided.    | .28    | .2400    | .0760       | 6.42      | 2.3500      | .0030     | .47              | 47,000                         |

Sewage applied, 2 gallons 6 times a week. Surface raked 3 inches deep each week. Experiments interrupted by high water May 4 to 8; May 18 to 20.

## FILTER No. 31.

This filter contains 30 inches in depth of medium fine sand of an effective size of 0.17 millimeter. It has received sewage at a uniform rate of 55,800 gallons per acre daily for six days in a week. The effluent has been uniformly well purified. No disturbance of the material, other than the weekly raking, has taken place since the filter was first put in operation May 31, 1890.

*Effluent from Filter No. 31.*

[Parts per 100,000.]

| 1893.        | Quantity Applied.<br><br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage Remained on Surface.<br>—<br>Hours and Minutes. | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|-------------------------------------------------------------------------|-------------------------|-----------|-----------------------------------------------------------------------|-------------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|              |                                                                         | Sewerage                | Effluent. |                                                                       | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |
|              |                                                                         |                         |           |                                                                       |             |        |          |             |           |             |           |                  |                                |
| January, .   | 55,800                                                                  | 48                      | 41        | 12m.                                                                  | None.       | .20    | .0356    | .0235       | 6.89      | 2.5400      | .0004     | .24              | 950                            |
| February, .  | 55,800                                                                  | 45½                     | 41½       | 16m.                                                                  | None.       | -      | .0181    | .0278       | 6.44      | 2.1900      | .0003     | .23              | 1,100                          |
| March, .     | 55,800                                                                  | 43                      | 41½       | 18m.                                                                  | None.       | .00    | .0175    | .0213       | 5.18      | 2.2650      | .0001     | .22              | 475                            |
| April, .     | 55,800                                                                  | 45                      | 44        | 15m.                                                                  | None.       | .17    | .0049    | .0226       | 5.97      | 2.5050      | .0000     | .24              | 172                            |
| May, .       | 47,500                                                                  | 53                      | 53½       | -                                                                     | None.       | .15    | .0147    | .0213       | 6.30      | 3.2433      | .0005     | .20              | 677                            |
| June, .      | 55,800                                                                  | 66                      | 64½       | 5m.                                                                   | None.       | .14    | .0118    | .0217       | 6.46      | 3.9500      | .0003     | .24              | 375                            |
| July, .      | 55,800                                                                  | 71                      | 71        | 6m.                                                                   | V. slight.  | .17    | .0301    | .0242       | 8.54      | 4.2900      | .0006     | .18              | 315                            |
| August, .    | 55,800                                                                  | 70                      | 71        | 9m.                                                                   | V. slight.  | .20    | .0084    | .0167       | 10.79     | 3.3900      | .0005     | .17              | 50                             |
| September, . | 55,800                                                                  | 63                      | 65        | 40m.                                                                  | V. slight.  | .15    | .0070    | .0206       | 12.60     | 2.3200      | .0002     | .18              | 90                             |
| October, .   | 55,800                                                                  | 56                      | 57        | 32m.                                                                  | V. slight.  | .21    | .0310    | .0256       | 8.16      | 2.7000      | .0014     | .25              | 1,384                          |
| November, .  | 55,800                                                                  | 45                      | 46½       | 3h. 30m.                                                              | V. slight.  | .21    | .0122    | .0244       | 17.10     | 2.2400      | .0002     | .19              | 360                            |
| December, .  | 55,800                                                                  | 41                      | 39        | 12h.                                                                  | None.       | .20    | .0248    | .0302       | 7.25      | 2.0000      | .0006     | .23              | 400                            |

Sewage applied, 2 gallons 6 times a week. Surface raked 3 inches deep each week. Experiments interrupted by high water May 5 to 8; May 18 to 20.

## FILTER No. 32.

This filter contains 30 inches in depth of medium fine sand of an effective size of 0.17 millimeter. It received the supernatant liquid from sewage treated by chemical precipitation like that applied to No. 19 at the rate of 112,000 gallons per acre daily for six days in a week. This rate was doubled on June 12 and that rate doubled October 23 (446,000 gallons). The filter became clogged in spite of frequent raking and scraping; this, with the deterioration in the quality of the effluent, indicated that this rate of filtration overtaxed the capacity of the filter, which was allowed to rest for two weeks beginning December 23.

*Effluent from Filter No. 32.*

[Parts per 100,000.]

| 1893.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage Remained on Surface.<br>Hours and Minutes. | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|------------------------------------------------------------------|-------------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|              |                                                                     | Sewage.                 | Effluent. |                                                                  | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |
| January, .   | 111,600                                                             | -                       | 40        | 1h. 30m.                                                         | None.       | .17    | .0031    | .0232       | 4.94      | 1.7100      | .0001     | .27              | 504                            |
| February, .  | 111,600                                                             | -                       | 41        | 1h.                                                              | None.       | .14    | .0996    | .0194       | 4.63      | 1.3325      | .0006     | .28              | 1,560                          |
| March, .     | 111,600                                                             | -                       | 41        | 1h. 30m.                                                         | None.       | .09    | .1711    | .0260       | 4.79      | 1.9040      | .0003     | .22              | 1,330                          |
| April, .     | 111,600                                                             | -                       | 46        | 1h.                                                              | None.       | .13    | .1350    | .0365       | 6.30      | 1.9075      | .0000     | .20              | 4,500                          |
| May, .       | 95,000                                                              | -                       | 55        | -                                                                | None.       | .14    | .0526    | .0280       | 5.76      | 2.3250      | .0001     | .18              | 6,625                          |
| June, .      | 186,800                                                             | -                       | 65        | 50m.                                                             | None.       | .13    | .0461    | .0372       | 13.19     | 1.8980      | .0000     | .19              | 2,328                          |
| July, .      | 223,200                                                             | -                       | 70        | 45m.                                                             | None.       | .16    | .0067    | .0286       | 8.70      | 1.1850      | .0000     | .24              | 274                            |
| August, .    | 223,200                                                             | -                       | 70        | 50m.                                                             | None.       | .13    | .0060    | .0224       | 7.36      | 1.0040      | .0000     | .25              | 175                            |
| September, . | 223,200                                                             | -                       | 62        | 2h. 45m.                                                         | None.       | .11    | .0179    | .0195       | 6.72      | 1.0625      | .0006     | .16              | 46                             |
| October, .   | 291,900                                                             | -                       | 56½       | 2h.                                                              | None.       | .11    | .3704    | .0877       | 10.75     | 1.5867      | .0013     | .19              | 5,833                          |
| November, .  | 446,400                                                             | -                       | 46        | 1h. 50m.                                                         | None.       | .23    | 1.7733   | .0733       | 9.43      | 1.2467      | .0049     | .35              | 15,713                         |
| December, .  | 343,200                                                             | -                       | 39½       | 1h. 50m.                                                         | None.       | .17    | 1.2875   | .0550       | 5.99      | 1.4150      | .0032     | .31              | 3,770                          |

Surface raked 3 inches deep each week until October 21. Experiments interrupted by high water May 5 to 8; May 18 to 20. Four gallons chemically clarified sewage applied, 6 times a week, till June 11; 2 gallons 24 times a week, June 12 to October 22; 2 gallons 48 times a week, October 23 to December 23, after which none was applied. Surface spaded 6 inches deep, November 20, December 12 and December 21. Surface scraped, and sand of previous scraping replaced (after washing) on following dates: October 21, November 7, 17, 24, 29, December 2, 18 and 21.

## FILTRATION OF WATER.

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One of the chief objects of water filtration, in most cases, is a removal of the disease-producing germs. The investigations by the Board in 1892 indicated that it is possible to construct filters which will yield 2,000,000 gallons of water per acre daily, and remove 99.5 per cent. of the bacteria in the applied water. The investigations were continued in 1893 with the view to learn the efficiency of the filters as they continued in service, and also to learn the bacterial efficiency of filters of coarser sands operated at higher rates of filtration.

The general plan of the experiments was the same as in 1892. Examination of the bacterial contents of the river water and of the effluent of each filter were made daily throughout the year. Owing to complications from freezing, which caused the formation of channels at the sides of the iron filter tanks during the winter months, and to the evolution of air by the saturated water within the filters, the results obtained from May to November, inclusive, alone will be discussed. Beginning May 12 *B. prodigiosus* was regularly applied to the filters ten hours daily and the effluent of each filter examined four or more times daily, at the time when the applied water containing this germ is passing through the outlet pipes. The reason that this germ was used is because it is easy to differentiate it from ordinary water bacteria and in its mode of life in the river water it appears to be very similar to the germ generally recognized as the cause of typhoid fever. In the table below is given a summary of the results obtained from the several filters. In the case of the older filters (Nos. 18 A to 42) the averages include all of the results; in the case of the remaining (new) filters the averages include all results after the second week of operation, when the efficiency in most cases became normal. The diameter of all of these filters is twenty inches and the area of filtering surface is equal to one twenty-thousandth of an acre. A detailed account of these results will be found beyond.

Summary of Bacterial Results obtained from the Several Water Filters, May 12 to Dec. 2, 1893.

| NUMBER OF FILTER. | Date of Construction. | Date of Discontinuance. | Effective Size of Sand. (Millimeter.) | Uniformity Coefficient. | Method of Operation.           | Depth of Material. (Inches.) | Average Rate of Filtration. Gallons per Acre Daily. | AVERAGE PER CENT. OF BACTERIA WHICH APPEARED IN EFFLUENT. |                       |
|-------------------|-----------------------|-------------------------|---------------------------------------|-------------------------|--------------------------------|------------------------------|-----------------------------------------------------|-----------------------------------------------------------|-----------------------|
|                   |                       |                         |                                       |                         |                                |                              |                                                     | Water Bacteria.                                           | Bacillus Prodigiosus. |
| 18 A.             | Sept. 17, 1899,       | -                       | 0.48                                  | 2.4                     | Intermittent.                  | 60                           | 1,880,000                                           | 3.25                                                      | 0.461                 |
| 33 A.             | April 28, 1892,       | -                       | 0.14                                  | 2.2                     | Continuous.                    | 60                           | 2,160,000                                           | 1.00                                                      | 0.086                 |
| 34 A.             | April 25, 1892,       | Sept. 7, 1893,          | 0.09                                  | 2.1                     | Continuous.                    | 45                           | 1,880,000                                           | 0.56                                                      | 0.022                 |
| 35 A.             | March 30, 1892,       | Sept. 6, 1893,          | 0.20                                  | 1.6                     | { Intermittent.<br>Continuous. | 48                           | 1,400,000                                           | 0.64                                                      | 0.049                 |
| 36 A.             | March 30, 1892,       | Sept. 6, 1893,          | 0.20                                  | 1.6                     | { Intermittent.<br>Continuous. | 48                           | 1,880,000                                           | 1.45                                                      | 0.054                 |
| 37.               | March 18, 1892,       | June 25, 1893,          | 0.20                                  | 1.6                     | Continuous.                    | 55                           | 2,420,000                                           | 0.31                                                      | 0.010                 |
| 38.               | April 28, 1892,       | -                       | 0.20                                  | 1.6                     | Continuous.                    | 20                           | 2,220,000                                           | 0.98                                                      | 0.061                 |
| 39.               | April 28, 1892,       | Aug. 19, 1893,          | 0.20                                  | 1.6                     | { Intermittent.<br>Continuous. | 1                            | 1,660,000                                           | 4.05                                                      | 0.762                 |
| 41.               | May 9, 1892,          | -                       | 0.14                                  | 2.2                     | Intermittent.                  | 60                           | 1,840,000                                           | 0.43                                                      | 0.039                 |
| 42.               | Oct. 29, 1892,        | -                       | 0.20                                  | 1.6                     | Continuous.                    | 10                           | 1,860,000                                           | 0.90                                                      | 0.050                 |
| 43.               | May 20, 1893,         | -                       | 0.26                                  | 3.7                     | Continuous.                    | 60                           | 4,848,000                                           | 1.07                                                      | 0.099                 |
| 44.               | May 20, 1893,         | -                       | 0.29                                  | 2.7                     | Continuous.                    | 60                           | 4,940,000                                           | 0.60                                                      | 0.083                 |
| 45.               | July 10, 1893,        | -                       | 0.23                                  | 2.3                     | Intermittent.                  | 60                           | 2,220,000                                           | 2.25                                                      | 0.290                 |
| 46.               | Aug. 21, 1893,        | -                       | 0.29                                  | 2.3                     | Continuous.                    | 12                           | 2,460,000                                           | 0.99                                                      | 0.169                 |
| 47.               | Sept. 9, 1893,        | -                       | 0.29                                  | 2.4                     | Intermittent.                  | 60                           | 3,580,000                                           | 3.41                                                      | 0.435                 |
| 48.               | Sept. 9, 1893,        | -                       | 0.38                                  | 3.5                     | Intermittent.                  | 60                           | 2,280,000                                           | 3.62                                                      | 0.501                 |
| 49.               | Sept. 9, 1893,        | -                       | 0.38                                  | 3.5                     | Continuous.                    | 60                           | 3,800,000                                           | 0.81                                                      | 0.160                 |

The results show that —

1. The bacterial efficiency of the older filters, all things considered, was as satisfactory in 1893 as it was during the preceding year.

2. A high degree of bacterial efficiency was attained by the new filters of coarser sand and operated at higher rates of filtration.

This is brought out more clearly by the following table, in which are summarized the results obtained from the newer and coarser filters for the four weeks ending December 2. The bacterial averages include the results of all examinations in each case and represent at least four samples daily taken at widely different hours.

*Summary of Bacterial Results obtained from Filters Nos. 43-49, with Rates of Filtration, November 6 to Dec. 2, 1893.*

| NUMBER OF FILTER. | Depth of Material.<br>Inches. | Method of Operation. | Average Rate of Filtration.<br>—<br>Gallons per Acre Daily. | AVERAGE PER CENT. OF NUMBER OF APPLIED BACTERIA WHICH APPEARED IN THE EFFLUENT. |                       |
|-------------------|-------------------------------|----------------------|-------------------------------------------------------------|---------------------------------------------------------------------------------|-----------------------|
|                   |                               |                      |                                                             | Water Bacteria.                                                                 | Bacillus Prodigiosus. |
| 43. . . . .       | 60                            | Continuous.          | 7,660,000                                                   | 1.48                                                                            | 0.171                 |
| 44. . . . .       | 60                            | Continuous.          | 7,700,000                                                   | 1.19                                                                            | 0.148                 |
| 45. . . . .       | 60                            | Intermittent.        | { 3,740,000<br>[6,640,000] }                                | 1.50                                                                            | 0.210                 |
| 46. . . . .       | 12                            | Continuous.          | 3,700,000                                                   | 2.34                                                                            | 0.337                 |
| 47. . . . .       | 60                            | Intermittent.        | { 3,660,000<br>[6,405,000] }                                | 3.13                                                                            | 0.463                 |
| 48. . . . .       | 60                            | Intermittent.        | { 2,900,000<br>[5,075,000] }                                | 1.83                                                                            | 0.366                 |
| 49. . . . .       | 60                            | Continuous.          | 5,550,000                                                   | 1.04                                                                            | 0.183                 |

The rates of filtration enclosed within the brackets are for the time when water was actually applied; the other rates are averages for the whole time, including the periods of rest.

These figures show that very good results were obtained from the newer experimental filters which were operated at much higher rates of filtration than those studied in 1892. This is particularly the case with Filters Nos. 43 and 44, which during the latter part of November were operated at rates of more than 9,000,000 gallons per acre daily, with a removal of over 98 per cent. of the applied water bacteria and over 99.5 per cent. of the applied *B. prodigiosus*.



### THE EFFECT UPON BACTERIAL PURIFICATION OF RATE OF FILTRATION OF WATER.

There are two views to this problem, first, the effect of differences in rates of filtration where the rate is kept constant after the change has once been made; and, second, the effect of fluctuating rates.

It is thought that the effect of changes in rates, which are regularly maintained after the change is made, is best shown by taking the average monthly results. The rates of filtration of the several filters were very seldom changed more than once in a month; they were not changed at all in some instances and all changes were moderate ones. When we consider the large number of bacteria stored in the sand the small differences in the number of bacteria in the applied water exert usually but little influence upon the numbers in the effluent and the results are therefore expressed in numbers per cubic centimeter.

*Average Monthly Results, showing the Number of Bacteria per Cubic Centimeter in the Effluents of the several Water Filters.*  
 [Rates expressed in million gallons per acre daily.]

| NUMBER OF FILTER. | Method of Operation. | MAY.  |                 |                        | JUNE. |                 |                        | JULY. |                 |                        | AUGUST. |                 |                        | SEPTEMBER. |                 |                        | OCTOBER. |                 |                        | NOVEMBER. |                 |                        |
|-------------------|----------------------|-------|-----------------|------------------------|-------|-----------------|------------------------|-------|-----------------|------------------------|---------|-----------------|------------------------|------------|-----------------|------------------------|----------|-----------------|------------------------|-----------|-----------------|------------------------|
|                   |                      | Rate. | Water Bacteria. | Bacillus Prodigiousus. | Rate. | Water Bacteria. | Bacillus Prodigiousus. | Rate. | Water Bacteria. | Bacillus Prodigiousus. | Rate.   | Water Bacteria. | Bacillus Prodigiousus. | Rate.      | Water Bacteria. | Bacillus Prodigiousus. | Rate.    | Water Bacteria. | Bacillus Prodigiousus. | Rate.     | Water Bacteria. | Bacillus Prodigiousus. |
| 38 A, .           | Intermittent.        | 1.5   | 24              | -                      | 2.3   | 18              | -                      | 1.7   | 222             | 58.0                   | 1.9     | 148             | 29.0                   | 1.7        | 2,375           | 19.5                   | 1.6      | 1,002           | 52.0                   | 1.8       | 167             | 11.5                   |
| 33 A, .           | Continuous.          | 1.7   | 8               | 0.7                    | 1.7   | 15              | 0.7                    | 1.9   | 98              | 2.5                    | 2.7     | 107             | 2.2                    | 1.9        | 53              | 2.0                    | 2.8      | 39              | 0.3                    | 2.8       | 29              | 0.9                    |
| 34 A, .           | Continuous.          | 1.6   | 9               | 1.7                    | 1.4   | 12              | 0.8                    | 1.9   | 24              | 1.2                    | 2.3     | 39              | 1.6                    | -          | -               | -                      | -        | -               | -                      | -         | -               | -                      |
| 35 A, .           | Intermittent.        | 1.4   | 17              | -                      | 1.2   | 9               | 1.9                    | 1.7   | 53              | 5.0                    | 3.0     | 22              | 3.6                    | -          | -               | -                      | -        | -               | -                      | -         | -               | -                      |
| 36 A, .           | Continuous.          | 2.0   | 10              | -                      | 2.0   | 12              | 0.3                    | 3.0   | 107             | 6.0                    | 1.7     | 157             | 3.8                    | -          | -               | -                      | -        | -               | -                      | -         | -               | -                      |
| 37, .             | Continuous.          | 1.7   | 7               | 0.0                    | 3.4   | 13              | 1.9                    | -     | -               | -                      | -       | -               | -                      | -          | -               | -                      | -        | -               | -                      | -         | -               | -                      |
| 38, .             | Continuous.          | 1.9   | 12              | 1.3                    | 1.7   | 17              | 1.2                    | 1.9   | 127             | 5.0                    | 2.5     | 84              | 3.3                    | 1.9        | 22              | 0.7                    | 2.0      | 29              | 0.1                    | 3.4       | 58              | 4.5                    |
| 39, .             | Continuous.          | 2.0   | 10              | 4.0                    | 1.6   | 35              | 9.9                    | 1.5   | 352             | 82.0                   | 1.7     | 318             | 89.0                   | -          | -               | -                      | -        | -               | -                      | -         | -               | -                      |
| 41, .             | Intermittent.        | 2.0   | 9               | 1.5                    | 1.5   | 10              | 1.5                    | 2.0   | 33              | 4.4                    | 1.9     | 39              | 5.4                    | 1.9        | 48              | 2.9                    | 1.8      | 19              | 0.5                    | 1.6       | 10              | 0.3                    |
| 42, .             | Continuous.          | 1.9   | 9               | 1.5                    | 1.7   | 10              | 1.5                    | 1.9   | 117             | 5.5                    | 1.9     | 55              | 2.8                    | 1.8        | 22              | 2.8                    | 2.0      | 13              | 1.4                    | 1.9       | 76              | 7.0                    |
| 43, .             | Continuous.          | 2.2   | 1,042           | 53.0                   | 3.9   | 316             | 6.0                    | 2.8   | 72              | 5.5                    | 4.3     | 26              | 6.0                    | 4.5        | 57              | 2.4                    | 4.8      | 46              | 8.4                    | 7.6       | 124             | 11.0                   |
| 44, .             | Continuous.          | 2.2   | 318             | 57.0                   | 2.8   | 128             | 12.0                   | 2.8   | 29              | 7.0                    | 4.3     | 29              | 6.0                    | 4.7        | 53              | 1.3                    | 5.8      | 22              | 1.9                    | 7.6       | 96              | 9.0                    |
| 45, .             | Intermittent.        | -     | -               | -                      | -     | -               | -                      | 1.5   | 680             | 92.0                   | 1.9     | 92              | 25.0                   | 1.7        | 725             | 8.5                    | 1.8      | 39              | 12.0                   | 3.6       | 119             | 12.0                   |
| 46, .             | Continuous.          | -     | -               | -                      | -     | -               | -                      | -     | -               | -                      | 2.0     | 65              | 1.3                    | 1.9        | 93              | 3.3                    | 2.3      | 41              | 18.0                   | 3.6       | 171             | 17.0                   |
| 47, .             | Intermittent.        | -     | -               | -                      | -     | -               | -                      | -     | -               | -                      | -       | -               | -                      | 1.7        | 2,396           | 176.0                  | 1.8      | 598             | 18.0                   | 3.6       | 213             | 25.0                   |
| 48, .             | Intermittent.        | -     | -               | -                      | -     | -               | -                      | -     | -               | -                      | -       | -               | -                      | 1.8        | 3,050           | 136.0                  | 1.8      | 663             | 33.0                   | 2.9       | 123             | 25.0                   |
| 49, .             | Continuous.          | -     | -               | -                      | -     | -               | -                      | -     | -               | -                      | -       | -               | -                      | 2.1        | 344             | 19.0                   | 2.6      | 112             | 7.0                    | 5.3       | 72              | 12.0                   |

In the case of No. 18 A the number of bacteria in the effluent increased about the middle of July after removing the siphon which delivered the water in one-quart doses onto the sand about once in four minutes days, nights and Sundays. After this time the water was applied sixteen hours a day and the filter allowed to drain during the remaining hours. Some of the bacterial increases during the summer were due to growths or to conditions favoring longer continuance of life of the bacteria in the sand. This was more marked in continuous than in intermittent filters.

In some cases there were marked increases in the number of bacteria in the effluent, evidently not due to changes in rates of filtration, and which at present cannot be fully accounted for. In other instances, such as Nos. 43 and 44, an increase in the rate was followed at times by no increase whatever in the number of bacteria in the effluent; and, when studied by weeks, some of the results indicate a diminution. These results, taken all together, indicate that in the process of water filtration there exist conditions which exert more influence upon the bacterial contents of the effluent than do differences in rates of filtration within moderate limits. Some of the conditions appear to be normal to the operations of these experimental filters while others are not yet understood. Upon examination of the results obtained at the highest rates, however, it will be seen that the bacterial efficiency diminishes and the statement made in earlier reports that low rates are safer than high rates is undoubtedly true. Nevertheless, up to a certain limit the rate apparently exerts very little influence, and this limit is different for different filters and also varies with other conditions in the case of the same filter.

*The Immediate Effect upon Bacterial Purification of Increasing the Rate of Filtration.*

In the next table are given the results obtained from each filter with regard to this point. Fluctuations in the rate of filtration appear to be an important feature in the operation of some of the older filters in Europe and the following results have been obtained at the Experiment Station upon this subject. The number of bacteria per cubic centimeter for each of the three days before and the three days after increasing the rate of filtration are given in each case where there was no complication such as the effect of scraping. In most cases the rate was increased and practically no information has

been obtained as to the effect of decreasing the rate. As the changes were usually made on Monday there are very few results for the first day before increasing the rate.

*Number of Bacteria per Cubic Centimeter.*

| NUMBER OF FILTER. | Date. 1893. | Change in Rate. Million Gallons per Acre Daily. | WATER BACTERIA.         |             |            |                        |             |            | BACILLUS PRODIGIOSUS.   |             |            |                        |             |            |
|-------------------|-------------|-------------------------------------------------|-------------------------|-------------|------------|------------------------|-------------|------------|-------------------------|-------------|------------|------------------------|-------------|------------|
|                   |             |                                                 | BEFORE INCREASING RATE. |             |            | AFTER INCREASING RATE. |             |            | BEFORE INCREASING RATE. |             |            | AFTER INCREASING RATE. |             |            |
|                   |             |                                                 | Third Day.              | Second Day. | First Day. | First Day.             | Second Day. | Third Day. | Third Day.              | Second Day. | First Day. | First Day.             | Second Day. | Third Day. |
| 33 A.             | June 1,     | 2-3                                             | 3                       | 4           | 8          | 19                     | 13          | 10         | 0.8                     | 0.2         | 0.3        | 0.5                    | 3.0         | 3.0        |
|                   | July 31,    | 2-3                                             | 278                     | 117         | -          | 95                     | 39          | 105        | 1.0                     | 2.0         | -          | 10.0                   | 4.0         | 4.0        |
|                   | Nov. 6,     | 2-3                                             | 9                       | 18          | -          | 21                     | 15          | 24         | 0.0                     | 0.0         | -          | 0.7                    | 0.0         | 0.7        |
|                   | Nov. 27,    | 3-4                                             | 20                      | 17          | -          | 83                     | 59          | 36         | 2.0                     | 0.6         | -          | 2.0                    | 3.0         | 5.0        |
|                   | Avg.,       |                                                 | 77                      | 39          | -          | 55                     | 32          | 44         | 0.9                     | 0.7         | -          | 3.3                    | 2.5         | 3.2        |
| 36 A.             | June 1,     | 2-3                                             | -                       | 5           | 4          | 6                      | 22          | 36         | -                       | -           | -          | -                      | -           | -          |
|                   | July 3,     | 1.5-3                                           | 45                      | 56          | -          | 185                    | 83          | 18         | 0.8                     | 0.0         | -          | 5.0                    | 0.5         | -          |
|                   | Avg.,       |                                                 | 45                      | 30          | -          | 95                     | 52          | 27         | 0.8                     | 0.0         | -          | 5.0                    | 0.5         | -          |
| 38.               | June 1,     | 2-3                                             | 5                       | 10          | 7          | 24                     | 15          | 10         | 0.8                     | 0.2         | 0.5        | 0.5                    | -           | 0.2        |
|                   | July 3,     | 1-2                                             | 87                      | 89          | -          | 49                     | 14          | 8          | 1.0                     | 1.0         | -          | 4.0                    | 2.0         | 4.0        |
|                   | Avg.,       |                                                 | 46                      | 40          | -          | 36                     | 15          | 9          | 0.9                     | 0.6         | -          | 2.3                    | 2.0         | 2.1        |
| 41.               | July 3,     | 1-2                                             | 11                      | 8           | -          | 28                     | 8           | 9          | 0.0                     | 1.0         | -          | 3.0                    | 2.0         | 1.0        |
| 42.               | June 1,     | 2-3                                             | 10                      | 9           | -          | 16                     | 13          | 10         | 0.8                     | 0.5         | -          | 2.0                    | 1.0         | 1.0        |
|                   | July 3,     | 1-2                                             | 19                      | 22          | -          | 14                     | 10          | -          | 3.0                     | 3.0         | -          | 7.0                    | 4.0         | -          |
|                   | Avg.,       |                                                 | 15                      | 15          | -          | 15                     | 12          | 10         | 1.9                     | 1.7         | -          | 4.5                    | 2.5         | 1.0        |
| 43.               | Aug. 21,    | 4-5                                             | 14                      | 49          | -          | 11                     | 7           | 12         | 4.0                     | 13.0        | -          | 5.0                    | 3.0         | 11.0       |
|                   | Oct. 25,    | 5-6                                             | -                       | -           | 36         | 44                     | 197         | 84         | -                       | -           | 19.0       | 14.0                   | 44.0        | 31.0       |
|                   | Avg.,       |                                                 | 14                      | 49          | 36         | 27                     | 102         | 48         | 4.0                     | 13.0        | -          | 10.0                   | 23.0        | 22.0       |
| 44.               | Aug. 21,    | 4-5                                             | 29                      | 23          | -          | 11                     | 4           | -          | 4.0                     | 4.0         | -          | 11.0                   | 3.0         | -          |
|                   | Oct. 25,    | 5-6                                             | 13                      | -           | 34         | 19                     | 18          | 14         | 0.3                     | -           | 1.0        | 8.0                    | 4.0         | 3.0        |
|                   | Avg.,       |                                                 | 21                      | 23          | 34         | 15                     | 11          | 14         | 2.1                     | 4.0         | -          | 9.5                    | 3.5         | 3.0        |
| 45.               | Nov. 6,     | 3-4                                             | 47                      | 30          | -          | 300                    | 115         | 81         | 9.0                     | 5.0         | -          | 6.0                    | -           | 16.0       |
|                   | Nov. 20,    | 4-6                                             | 35                      | 32          | -          | 115                    | 80          | -          | 3.0                     | 4.0         | -          | 15.0                   | 19.0        | 28.0       |
|                   | Avg.,       |                                                 | 42                      | 31          | -          | 208                    | 97          | 81         | 6.0                     | 4.5         | -          | 10.5                   | 19.0        | 22.0       |
| 46.               | Oct. 23,    | 2-3                                             | 25                      | 18          | -          | 13                     | 14          | 24         | 3.0                     | 4.0         | -          | 5.0                    | 4.0         | 3.0        |

Summary of Bacteria per Cubic Centimeter — Continued

| Date | Hour | No. of<br>cubes<br>per cent. | Water Analysis         |            |           | Bacterial Productions |            |           | Bacterial Productions  |            |           |
|------|------|------------------------------|------------------------|------------|-----------|-----------------------|------------|-----------|------------------------|------------|-----------|
|      |      |                              | Before Increasing Rate |            |           | After Increasing Rate |            |           | Before Increasing Rate |            |           |
|      |      |                              | Third Day              | Second Day | First Day | Third Day             | Second Day | First Day | Third Day              | Second Day | First Day |
| 8    | 2.00 | 2                            | 25                     | 25         | -         | 25                    | 25         | 25        | 25                     | 25         | 25        |
|      | 2.00 | 2                            | 25                     | 25         | -         | 25                    | 25         | 25        | 25                     | 25         | 25        |
| Avg  |      |                              | 25                     | 25         | -         | 25                    | 25         | 25        | 25                     | 25         | 25        |
| 9    | 2.00 | 2                            | 25                     | 25         | -         | 25                    | 25         | 25        | 25                     | 25         | 25        |
|      | 2.00 | 2                            | 25                     | 25         | -         | 25                    | 25         | 25        | 25                     | 25         | 25        |
| Avg  |      |                              | 25                     | 25         | -         | 25                    | 25         | 25        | 25                     | 25         | 25        |

Summary of Bacteria Results to Show the Immediate Effect of Increasing the Rate of Filtration

| Results of Filtration | Water Analysis         |            |           | Bacterial Productions |            |           | Bacterial Productions  |            |           |
|-----------------------|------------------------|------------|-----------|-----------------------|------------|-----------|------------------------|------------|-----------|
|                       | Before Increasing Rate |            |           | After Increasing Rate |            |           | Before Increasing Rate |            |           |
|                       | Third Day              | Second Day | First Day | Third Day             | Second Day | First Day | Third Day              | Second Day | First Day |
| 10 A.                 | 77                     | 20         | -         | 55                    | 22         | 44        | 6.5                    | 1.7        | -         |
| 10 A.                 | 65                     | 20         | -         | 95                    | 22         | 27        | 6.5                    | 1.7        | -         |
| 10 A.                 | 65                     | 90         | -         | 25                    | 15         | 9         | 6.5                    | 6.5        | -         |
| 11                    | 11                     | 5          | -         | 25                    | 5          | 9         | 0.0                    | 1.0        | -         |
| 12                    | 15                     | 15         | -         | 16                    | 12         | 19        | 1.5                    | 1.7        | -         |
| 1                     | 14                     | 49         | 25        | 27                    | 102        | 45        | 4.0                    | 13.0       | -         |
| 10                    | 21                     | 25         | 34        | 15                    | 11         | 14        | 2.1                    | 4.0        | -         |
| 1                     | 42                     | 21         | -         | 205                   | 97         | 81        | 6.0                    | 4.5        | -         |
| 10                    | 25                     | 15         | -         | 15                    | 14         | 24        | 3.0                    | 4.0        | -         |
| 11                    | 115                    | 75         | -         | 250                   | 252        | 660       | 24.0                   | 17.0       | -         |
| 12                    | 180                    | 82         | -         | 250                   | 167        | 172       | 22.0                   | 22.0       | -         |
| Average               | 49                     | 37         | -         | 102                   | 78         | 100       | 6.0                    | 6.4        | -         |

These results show that in a majority of cases an increase in the number of bacteria in the effluent followed an increase, within these limits, in the rate of filtration. This is more noticeable in filters of coarse material than in those of fine, and shows an advantage of uniformity in the operation of water filters.

# THE EFFECT OF DEPTH OF MATERIAL UPON BACTERIAL PURIFICATION OF WATER.

The results upon this point are as follows : —

| NUMBER OF FILTER. | Depth.<br>Inches. | Effective<br>Size of<br>Grain.<br>—<br>Millimeter. | Period — 1893.     | Rate.<br>—<br>Million<br>Gallons<br>per Acre<br>Daily. | AVERAGE PER CENT. OF<br>NUMBER OF<br>APPLIED BACTERIA<br>WHICH APPEARED IN THE<br>EFFLUENTS. |                          |
|-------------------|-------------------|----------------------------------------------------|--------------------|--------------------------------------------------------|----------------------------------------------------------------------------------------------|--------------------------|
|                   |                   |                                                    |                    |                                                        | Water<br>Bacteria.                                                                           | Bacillus<br>Prodigiosus. |
| 44, . . . . .     | 60                | 0.29                                               | May 20 to Dec. 2,  | 4.9                                                    | 0.60                                                                                         | 0.083                    |
| 46, . . . . .     | 12                | 0.29                                               | Aug. 21 to Dec. 2, | 2.5                                                    | 0.99                                                                                         | 0.169                    |
| 44, . . . . .     | 60                | 0.29                                               | Nov. 6 to Dec. 2,  | 7.7                                                    | 1.19                                                                                         | 0.148                    |
| 46, . . . . .     | 12                | 0.29                                               | Nov. 6 to Dec. 2,  | 3.7                                                    | 2.34                                                                                         | 0.337                    |
| 27, . . . . .     | 55                | 0.20                                               | May 12 to June 25, | 2.4                                                    | 0.31                                                                                         | 0.010                    |
| 33, . . . . .     | 20                | 0.20                                               | May 12 to Dec. 2,  | 2.2                                                    | 0.98                                                                                         | 0.061                    |
| 39, . . . . .     | 1                 | 0.20                                               | May 12 to Aug. 19, | 1.7                                                    | 4.06                                                                                         | 0.762                    |
| 42, . . . . .     | 10                | 0.20                                               | May 12 to Dec. 2,  | 1.9                                                    | 0.90                                                                                         | 0.050                    |

The results obtained from Filters Nos. 44 and 46 show that the deeper filter is the more effective, although the filter one foot deep gave quite satisfactory results, especially at the lower rate of filtration. Upon consideration of the second series it is seen that No. 37, the deepest filter, was the most effective while the shallowest one, No. 39, was the least efficient in removing bacteria. No. 39 contained 5 inches of underdrain (stones, gravel and coarse sand) in addition to the inch of sand. Of the two filters, Nos. 38 and 42, 20 and 10 inches deep, respectively, the shallower was very slightly the more efficient. It is to be noted that when the filters were restored to their original depth, by the addition in some cases of a foot of sand, there was no apparent effect upon the bacterial contents of the effluents. We must conclude, however, all things considered, that while very satisfactory results may be obtained, under favorable conditions, from filters one to two feet deep, the deeper filters are safer than the shallower ones.

### THE EFFECT OF SIZE OF SAND GRAINS UPON BACTERIAL PURIFICATION.

In the following table is given a summary of the results obtained from the several filters during the month of November, this month affording the fairest comparison because the conditions were then most nearly alike.

#### *Continuous Filters.*

| NUMBER OF FILTER.      | Effective Size of Grain.<br>—<br>Millimeter. | Estimated Maximum Rate.<br>—<br>Million Gallons per Acre Daily. | Average Rate.<br>—<br>Million Gallons per Acre Daily. | BACTERIA PER CUBIC CENTIMETER IN EFFLUENTS. |                |
|------------------------|----------------------------------------------|-----------------------------------------------------------------|-------------------------------------------------------|---------------------------------------------|----------------|
|                        |                                              |                                                                 |                                                       | Water Bacteria.                             | B. Prodigiosa. |
| 33 A, . . . . .        | 0.14                                         | 16                                                              | 2.8                                                   | 29                                          | 1              |
| 38 (2 feet), . . . . . | 0.20                                         | 32                                                              | 3.4                                                   | 58                                          | 5              |
| 43, . . . . .          | 0.26                                         | 53                                                              | 7.6                                                   | 124                                         | 11             |
| 44, . . . . .          | 0.29                                         | 67                                                              | 7.6                                                   | 96                                          | 9              |
| 49, . . . . .          | 0.38                                         | 116                                                             | 5.3                                                   | 72                                          | 12             |

#### *Intermittent Filters.*

|                 |      |     |     |     |    |
|-----------------|------|-----|-----|-----|----|
| 41, . . . . .   | 0.14 | 16  | 1.6 | 10  | 1  |
| 45, . . . . .   | 0.23 | 42  | 3.6 | 120 | 12 |
| 47, . . . . .   | 0.29 | 67  | 3.6 | 213 | 25 |
| 48, . . . . .   | 0.38 | 116 | 2.9 | 123 | 23 |
| 18 A, . . . . . | 0.48 | 184 | 1.8 | 167 | 11 |

These results indicate that, within the limits in sizes of sand grains which would be ordinarily employed in filtration, the finer sands are slightly more efficient in removing bacteria than the coarser ones. It appears, however, that there are conditions sometimes attending the process of filtration which disguise and at times completely offset the slight advantages which arise from fineness of material.

### THE EFFECT OF SCRAPING FILTERS UPON BACTERIAL PURIFICATION OF WATER.

It was shown in the Annual Report for 1892 that there was a slight increase in the number of bacteria in the effluent after a filter had been scraped. The method of scraping the continuous filters followed

in 1892 was practised in 1893 until November 1, as follows: the water above the sand was siphoned off and the filter allowed to drain until the water stood about an inch below the surface of the sand. The outlet was then closed, the surface scraped and water applied slowly from the top. The intermittent filters were scraped after draining. In the table below is given a summary, up to November, of the number of bacteria in the effluent during each of the three days before and three days after scraping, and also of the remaining days of each period between scrapings. In some instances the filters were scraped about once a week and nearly all of the results are contained under the headings, three days before and three days after scraping; under these circumstances a representative result for the time midway between scrapings is given under the column, remaining days.

*Summary of the Average Results of the Number of Bacteria per Cubic Centimeter in the Effluent of each Filter during Different Portions of each Period between Scrapings.*

| NUMBER OF<br>FILTER. | Maximum<br>Loss<br>of Head.<br>Inches. | Number<br>of<br>Times<br>Scraped. | WATER BACTERIA. |                     |             |            |                    |             |            |                 |                     | BACILLUS PRODIGIOSUS. |            |                    |             |            |  |  |  |  |
|----------------------|----------------------------------------|-----------------------------------|-----------------|---------------------|-------------|------------|--------------------|-------------|------------|-----------------|---------------------|-----------------------|------------|--------------------|-------------|------------|--|--|--|--|
|                      |                                        |                                   | Remaining Days. | BEFORE<br>SCRAPING. |             |            | AFTER<br>SCRAPING. |             |            | Remaining Days. | BEFORE<br>SCRAPING. |                       |            | AFTER<br>SCRAPING. |             |            |  |  |  |  |
|                      |                                        |                                   |                 | Third Day.          | Second Day. | First Day. | First Day.         | Second Day. | Third Day. |                 | Third Day.          | Second Day.           | First Day. | First Day.         | Second Day. | Third Day. |  |  |  |  |
|                      |                                        |                                   |                 |                     |             |            |                    |             |            |                 |                     |                       |            |                    |             |            |  |  |  |  |
| 33 A, . .            | 70                                     | 7                                 | 35              | 39                  | 101         | 51         | 34                 | 56          | 60         | 1.4             | 1.3                 | 0.4                   | 0.7        | 1.0                | 2.2         | 2.4        |  |  |  |  |
| 34 A, . .            | 70                                     | 17                                | 18              | 21                  | 13          | 33         | 39                 | 16          | 18         | 1.5             | 1.5                 | 2.2                   | 1.4        | 1.6                | 1.0         | 1.4        |  |  |  |  |
| 35 A, . .            | 70                                     | 3                                 | 23              | 36                  | 7           | 25         | 26                 | 79          | 40         | 2.5             | 0.1                 | 0.0                   | 0.0        | 6.0                | 5.0         | 5.0        |  |  |  |  |
| 36 A, . .            | 70                                     | 6                                 | 104             | 110                 | 64          | 103        | 91                 | 104         | 39         | 6.0             | 1.5                 | 3.9                   | 1.3        | 2.3                | 1.8         | 3.9        |  |  |  |  |
| 38, . . .            | 35                                     | 16                                | 64              | 74                  | 50          | 67         | 48                 | 42          | 35         | 2.1             | 2.0                 | 2.2                   | 2.5        | 4.1                | 1.9         | 2.7        |  |  |  |  |
| 39, . . .            | 23                                     | 11                                | 182             | 167                 | 125         | 244        | 265                | 263         | 212        | 40.0            | 42.2                | 52.4                  | 56.7       | 60.0               | 90.0        | 24.0       |  |  |  |  |
| 41, . . .            | 70                                     | 5                                 | 22              | 10                  | 15          | 30         | 59                 | 52          | 146        | 2.9             | 0.7                 | 0.6                   | 0.0        | 1.6                | 2.3         | 3.0        |  |  |  |  |
| 42, . . .            | 23                                     | 19                                | 33              | 46                  | 33          | 156        | 40                 | 32          | 17         | 1.7             | 1.2                 | 2.0                   | 1.8        | 6.0                | 3.8         | 2.5        |  |  |  |  |
| 43, . . .            | 70                                     | 12                                | 55              | 68                  | 53          | 82         | 82                 | 72          | 61         | 2.9             | 2.4                 | 1.8                   | 2.3        | 5.2                | 4.0         | 4.3        |  |  |  |  |
| 44, . . .            | 70                                     | 9                                 | 19              | 19                  | 53          | 53         | 65                 | 46          | 35         | 2.7             | 3.8                 | 3.9                   | 3.8        | 10.8               | 6.5         | 2.9        |  |  |  |  |
| 45, . . .            | 70                                     | 2                                 | 110             | 50                  | 40          | 32         | 93                 | 118         | 202        | 27.0            | 54.0                | 26.0                  | 15.0       | 24.0               | 16.0        | 12.0       |  |  |  |  |
| 46, . . .            | 70                                     | 5                                 | 95              | 43                  | 58          | 53         | 88                 | 121         | 31         | 3.1             | 4.1                 | 3.7                   | 2.9        | 5.6                | 4.5         | 3.8        |  |  |  |  |
| 49, . . .            | 70                                     | 1                                 | 125             | 90                  | 48          | 33         | 213                | 64          | -          | 3.7             | 2.0                 | 2.0                   | 3.0        | 22.0               | 18.0        | -          |  |  |  |  |
| Tot's and Av's,      | -                                      | 113                               | 68              | 60                  | 51          | 74         | 88                 | 82          | 75         | 7.5             | 9.0                 | 7.8                   | 7.0        | 11.5               | 12.1        | 5.6        |  |  |  |  |



The average results from all of the filters indicate that there was a very slight decrease in bacterial efficiency, after scraping, by the method of operation practised. Taking the results individually it was found that out of 113 scrapings an increase in the number of bacteria in the effluents just after scraping, above that accounted for by the ordinary bacterial fluctuations, occurred in the case of the water bacteria 46 times and in the case of *B. prodigiosus* 55 times. Almost without exception the increase in number of bacteria was very slight, as will be seen in the table below, which contains the results obtained from each filter when the effect of scraping was most marked. In the second table beyond are given the results when the effect of scraping was the least marked in the case of each filter. During the period in which the results given in these tables were obtained the water bacteria in the applied water averaged 10,500 and the *B. prodigiosus* 7,000 per cubic centimeter.

*Table showing the Number of Bacteria per Cubic Centimeter in the Effluent of Each Filter during Different Portions of the Period between Scrapings when the Effect of Scraping was Most Marked.*

| NUMBER<br>OF<br>FILTER. | WATER BACTERIA. |                  |             |            |                 |             |            | BACILLUS PRODIGIOSUS. |                  |             |            |                 |             |            |
|-------------------------|-----------------|------------------|-------------|------------|-----------------|-------------|------------|-----------------------|------------------|-------------|------------|-----------------|-------------|------------|
|                         | Remaining Days. | BEFORE SCRAPING. |             |            | AFTER SCRAPING. |             |            | Remaining Days.       | BEFORE SCRAPING. |             |            | AFTER SCRAPING. |             |            |
|                         |                 | Third Day.       | Second Day. | First Day. | First Day.      | Second Day. | Third Day. |                       | Third Day.       | Second Day. | First Day. | First Day.      | Second Day. | Third Day. |
| 33 A, .                 | 51              | 82               | 43          | 27         | 45              | 118         | -          | 1.8                   | 0.0              | 0.0         | 0.0        | 1.0             | 3.0         | -          |
| 34 A, .                 | 14              | 7                | 6           | -          | 108             | 19          | 23         | 3.0                   | 2.0              | 2.0         | -          | 3.0             | 1.0         | 3.0        |
| 35 A, .                 | 12              | 12               | 2           | 3          | 16              | 14          | -          | 0.4                   | 0.0              | 0.0         | 0.0        | 5.0             | 8.0         | -          |
| 36 A, .                 | 117             | 76               | 114         | 227        | 329             | 168         | -          | 0.8                   | 1.0              | 0.3         | 1.0        | 1.0             | 2.0         | -          |
| 38, . .                 | 15              | 8                | 8           | 6          | 20              | 8           | 5          | 2.0                   | 3.0              | 3.0         | 2.0        | 8.0             | 0.5         | 0.0        |
| 39, . .                 | 11              | -                | 9           | 9          | 36              | 16          | 36         | 7.0                   | -                | 9.0         | 4.0        | 9.0             | 21.0        | 9.0        |
| 41, . .                 | 19              | 8                | 20          | 17         | 148             | 98          | 282        | 1.4                   | 0.3              | 0.3         | -          | 3.0             | 2.0         | 4.0        |
| 42, . .                 | 7               | -                | 12          | 5          | 63              | 24          | 16         | 0.0                   | -                | 0.0         | 1.0        | 18.0            | 15.0        | 13.0       |
| 43, . .                 | 22              | -                | 11          | 7          | 12              | 47          | 14         | 5.6                   | -                | 5.0         | 3.0        | 11.0            | 1.0         | 1.0        |
| 44, . .                 | 19              | -                | 11          | 4          | 35              | 109         | 39         | 3.0                   | -                | 11.0        | 3.0        | 9.0             | 3.0         | 2.0        |
| 45, . .                 | 82              | -                | -           | 26         | 69              | 163         | 351        | 12.0                  | -                | -           | 2.0        | 17.0            | 12.0        | 3.0        |
| 46, . .                 | 43              | -                | -           | 80         | 172             | 395         | 26         | 3.0                   | -                | -           | 1.0        | 10.0            | 7.0         | 4.0        |
| Av's, .                 | 34              | -                | -           | 37         | 88              | 98          | -          | 3.3                   | -                | -           | 2.1        | 7.5             | 6.3         | -          |

Table showing the Number of Bacteria per Cubic Centimeter in the Effluent of Each Filter during Different Portions of the Period between Scrapings when the Effect of Scraping was Least Marked.

| NUMBER<br>OF<br>FILTER. | WATER BACTERIA. |                  |             |            |                 |             |            |                 |      | BACILLUS PRODIGIOSUS. |             |            |                 |             |            |  |  |  |
|-------------------------|-----------------|------------------|-------------|------------|-----------------|-------------|------------|-----------------|------|-----------------------|-------------|------------|-----------------|-------------|------------|--|--|--|
|                         | Remaining Days. | BEFORE SCRAPING. |             |            | AFTER SCRAPING. |             |            | Remaining Days. |      | BEFORE SCRAPING.      |             |            | AFTER SCRAPING. |             |            |  |  |  |
|                         |                 | Third Day.       | Second Day. | First Day. | First Day.      | Second Day. | Third Day. |                 |      | Third Day.            | Second Day. | First Day. | First Day.      | Second Day. | Third Day. |  |  |  |
| 33 A, .                 | 9               | 10               | -           | 16         | 17              | 6           | 8          | 1.0             | 3.0  | -                     | 0.2         | 0.2        | 0.0             | 0.8         |            |  |  |  |
| 34 A, .                 | 8               | 8                | 4           | 8          | 7               | 7           | 10         | 0.2             | 0.2  | 4.0                   | 4.0         | 0.5        | 2.0             | 1.0         |            |  |  |  |
| 35 A, .                 | 40              | -                | 11          | 13         | 6               | 60          | 36         | 5.6             | -    | 0.0                   | 0.0         | 0.0        | 0.0             | 0.0         |            |  |  |  |
| 36 A, .                 | 64              | -                | 5           | 2          | 5               | 2           | 5          | 2.0             | -    | 0.0                   | 0.0         | 0.0        | 0.0             | 0.0         |            |  |  |  |
| 38, .                   | 18              | 37               | -           | 30         | 8               | 6           | 8          | 1.0             | 1.0  | -                     | 2.0         | 1.0        | 0.3             | 0.0         |            |  |  |  |
| 39, .                   | 45              | 11               | 49          | 42         | 17              | 16          | -          | 3.0             | 10.0 | 4.0                   | 2.0         | 4.0        | 3.0             | -           |            |  |  |  |
| 41, .                   | 13              | 8                | 9           | 12         | 26              | 21          | -          | 1.0             | 2.0  | 1.0                   | -           | 2.0        | 3.0             | -           |            |  |  |  |
| 42, .                   | 16              | 9                | 9           | 12         | 10              | 10          | 4          | 1.6             | 0.0  | 0.0                   | 2.0         | 0.8        | 1.0             | 0.2         |            |  |  |  |
| 43, .                   | 28              | 37               | 26          | 40         | 19              | -           | 18         | 1.0             | 0.5  | 0.5                   | 1.0         | 2.0        | 2.0             | 1.0         |            |  |  |  |
| 44, .                   | 27              | 10               | -           | -          | 6               | 3           | 4          | 0.5             | 0.0  | -                     | -           | 0.0        | 1.0             | 2.0         |            |  |  |  |
| 45, .                   | 137             | 50               | 40          | 37         | 117             | 73          | 54         | 41.0            | 54.0 | 26.0                  | 28.0        | 31.0       | 20.0            | 21.0        |            |  |  |  |
| 46, .                   | 38              | 15               | -           | 30         | 43              | 17          | 23         | 3.1             | 0.3  | -                     | 1.5         | 3.0        | 4.0             | 7.0         |            |  |  |  |
| Av., .                  | 37              | -                | -           | 22         | 23              | 20          | -          | 5.2             | -    | -                     | 3.7         | 3.8        | 3.3             | -           |            |  |  |  |

#### THE EFFECT UPON BACTERIAL PURIFICATION OF DISTURBING THE UPPER TWELVE INCHES OF FILTERS OF FINE MATERIAL.

Filters No. 33 A (continuous) and 41 (intermittent), containing 48 inches in depth of sand of an effective size of 0.14 millimeter, were scraped on July 17, after draining. This sand is so fine that the lower portion of the filter remains saturated after draining. The upper 12 inches of material were taken out and replaced. Water was applied at the top of the continuous filter, with the outlet closed, and after the surface was covered the faucet below was opened to give the usual rate of two million gallons per acre daily. The faucet of the intermittent filter was kept wide open and the rate of filtration regulated at the top.

In the following table are given the bacterial results from these filters for the week preceding and the week following this treatment. No *B. prodigiosus* was applied on July 17; the results on that day represent drainings. On all other days the results are averages of four examinations.

*Bacteria per Cubic Centimeter.*

| DATE — 1893.       | APPLIED WATER.  |                        | EFFLUENT OF FILTER No. 35 A. |                        | EFFLUENT OF FILTER No. 41. |                        |
|--------------------|-----------------|------------------------|------------------------------|------------------------|----------------------------|------------------------|
|                    | Water Bacteria. | Bacillus Prodigiousus. | Water Bacteria.              | Bacillus Prodigiousus. | Water Bacteria.            | Bacillus Prodigiousus. |
| July 10, . . . . . | 2,100           | 8,000                  | 12                           | 0.3                    | 11                         | 2.0                    |
| 11, . . . . .      | 8,300           | 5,200                  | 18                           | 0.5                    | 20                         | 0.7                    |
| 12, . . . . .      | 6,100           | 6,000                  | 102                          | 0.3                    | 75                         | 3.0                    |
| 13, . . . . .      | 7,500           | 5,700                  | 39                           | 3.0                    | 43                         | 3.0                    |
| 14, . . . . .      | 4,400           | 4,300                  | 40                           | 2.0                    | 18                         | 1.0                    |
| 15, . . . . .      | 2,800           | 6,700                  | 77                           | 2.0                    | 13                         | 0.7                    |
| 17, . . . . .      | 1,000           | 0                      | 47                           | 0.0                    | 23                         | 0.0                    |
| 18, . . . . .      | 1,900           | 5,700                  | 16                           | 4.0                    | 33                         | 6.0                    |
| 19, . . . . .      | 7,700           | 5,200                  | 24                           | 3.0                    | 46                         | 4.0                    |
| 20, . . . . .      | 10,000          | 9,700                  | 19                           | 3.0                    | 33                         | 11.0                   |
| 21, . . . . .      | 5,900           | 6,300                  | 23                           | 2.0                    | 53                         | 11.0                   |
| 22, . . . . .      | 3,300           | 6,700                  | 6                            | 1.0                    | 36                         | 3.0                    |

THE EFFECT UPON BACTERIAL PURIFICATION OF REMOVING AN INCH LAYER OF LOAM TWO INCHES BELOW THE SURFACE OF AN INTERMITTENT FILTER OF MEDIUM FINE SAND.

Filter No. 35 A contained 48 inches in depth of sand of an effective size of 0.20 millimeter. After draining, on July 17 the surface was scraped, the loam layer 2 inches below the surface taken out and the sand replaced. The faucet below was kept wide open and the rate of the applied water regulated at the top. The bacterial results before and after this treatment were as follows:—

*Bacteria per Cubic Centimeter.*

| DATE — 1893.       | APPLIED WATER.  |                        | EFFLUENT OF FILTER No. 35 A. |                        |
|--------------------|-----------------|------------------------|------------------------------|------------------------|
|                    | Water Bacteria. | Bacillus Prodigiousus. | Water Bacteria.              | Bacillus Prodigiousus. |
| July 10, . . . . . | 2,100           | 8,000                  | 9                            | 1.0                    |
| 11, . . . . .      | 8,300           | 5,200                  | 7                            | 0.0                    |
| 12, . . . . .      | 6,100           | 6,000                  | 17                           | 0.3                    |
| 13, . . . . .      | 7,500           | 5,700                  | 27                           | 0.5                    |
| 14, . . . . .      | 4,400           | 4,300                  | 64                           | 0.0                    |
| 15, . . . . .      | 2,800           | 6,700                  | 60                           | 0.3                    |
| 17, . . . . .      | 1,000           | 0                      | 59                           | 0.0                    |
| 18, . . . . .      | 1,900           | 5,700                  | 57                           | 13.0                   |
| 19, . . . . .      | 7,700           | 5,200                  | 164                          | 7.0                    |
| 20, . . . . .      | 10,000          | 9,700                  | 44                           | 10.0                   |
| 21, . . . . .      | 5,900           | 6,300                  | 81                           | 13.0                   |
| 22, . . . . .      | 3,300           | 6,700                  | 52                           | 7.0                    |

The results presented in the last two tables indicate that a slight decrease in bacterial efficiency follows a mechanical disturbance of the upper portion of fine filters and the removal of a layer of fine loam. From our general knowledge of the efficiency of coarser

filters it is probable that in such cases the diminution would be more marked. The effect of mechanical disturbance is brought out most clearly by the results obtained from Filters Nos. 3 B and 8 A.

These filters are one two-hundredth of an acre in area and contain five feet in depth of sand of an effective size of 0.23 millimeter. Filter No. 3 B has been operated intermittently at an average rate of two million gallons per acre daily since September 23, as follows: at 5 A.M. the gate on the outlet pipe is closed and the water turned on at the top near the edge. When the filter is covered (about 7.30 A.M.) the gate on the outlet pipe is opened to give the prescribed rate of filtration, and the surface is kept covered until 9 P.M. when the water is shut off and the filter allowed to drain during the night. No. 8 A has been operated continuously since September 26 at a constant rate of two million gallons per acre daily. While the passage of water through No. 8 A is uniform and causes no disturbance of the sand, the peculiar method of daily filling in No. 3 B drives out a large part of the air contained in the sand and causes more or less disturbance of the sand at the surface. That this disturbance of the surface is due to the escape of air from the sand can be readily seen from inspection, and is further indicated by the fact that up to January 1, No. 8 A was scraped three times to relieve clogging, while No. 3 B was not scraped at all during this period, although it yielded as much water. In the table below are given the average results of daily bacterial examinations of samples taken at different hours during the day from the effluent of each filter, from October 30 to December 8. The number of bacteria per cubic centimeter in the applied water averaged 8,800 during this period.

*Bacteria per Cubic Centimeter.*

| DATE.<br>(OCTOBER 30 TO DEC. 8, 1888.)                               | EFFLUENT OF FILTER NO. 3B.<br>(INTERMITTENT.) |         |        |        | EFFLUENT OF FILTER NO. 8A.<br>(CONTINUOUS.) |         |        |        |
|----------------------------------------------------------------------|-----------------------------------------------|---------|--------|--------|---------------------------------------------|---------|--------|--------|
|                                                                      | 8 A.M.                                        | 11 A.M. | 2 P.M. | 4 P.M. | 8 A.M.                                      | 11 A.M. | 2 P.M. | 4 P.M. |
| Hour, . . . . .                                                      |                                               |         |        |        |                                             |         |        |        |
| Bacteria in effluents, . . . .                                       | 329                                           | 286     | 185    | 140    | 104                                         | 119     | 126    | 103    |
| Per cent. of number of applied bacteria which appeared in effluents, | 3.63                                          | 3.25    | 2.10   | 1.59   | 1.18                                        | 1.35    | 1.48   | 1.17   |

The diminished efficiency of No. 3 B in the forenoon appears to be due to the mechanical disturbance of the main body of the sand by the escaping air.

### THE EFFECT UPON BACTERIAL PURIFICATION OF FREEZING THE SURFACE LAYERS OF A FILTER.

The freezing of the upper layers of a filter which has been drained also appears to aid in causing the passage of more bacteria through the filter. The weather during the second and third week in December was very cold and the surface of No. 3 B froze during the night after draining. The last week in the month was much warmer. Upon comparison of the results below with those presented above it will be seen that No. 3 B was less efficient than usual during the severe weather, but the results became normal again when warmer weather appeared.

*Average Weekly Numbers of Bacteria per Cubic Centimeter.*

| WEEK ENDING—           | EFFLUENT OF FILTER No. 3 B.<br>(INTERMITTENT.) |         |        |        | EFFLUENT OF FILTER No. 3 A.<br>(CONTINUOUS.) |         |        |        |
|------------------------|------------------------------------------------|---------|--------|--------|----------------------------------------------|---------|--------|--------|
|                        | 8 A.M.                                         | 11 A.M. | 2 P.M. | 4 P.M. | 8 A.M.                                       | 11 A.M. | 2 P.M. | 4 P.M. |
| <b>1893.</b>           |                                                |         |        |        |                                              |         |        |        |
| December 16, . . . . . | 259                                            | 236     | 310    | 273    | 40                                           | 51      | 50     | 78     |
| 23, . . . . .          | 297                                            | 232     | 249    | 393    | 86                                           | 82      | 92     | 102    |
| 30, . . . . .          | 285                                            | 263     | 159    | 147    | 74                                           | 63      | 68     | 66     |

### EFFECT UPON BACTERIAL PURIFICATION OF RAPIDLY FILLING FILTERS FROM BELOW AFTER DRAINING.

During November several of the small filters, when their pores contained more or less air, were filled from below with filtered water. It is not known definitely how fast the water flowed into the filters, but in a majority of cases the rate was high, — probably equivalent to 5,000,000 gallons per acre daily or more.

More information is needed upon this point, but from the results given below it is clear that by rapidly filling a filter from below it is possible to disturb the sand so that the bacterial efficiency will be much diminished upon resuming filtration.

In the case of the several filters in question the numbers of bacteria in the effluents during the three days before and three days after filling from below are as follows: —

*Average Daily Numbers of Bacteria per Cubic Centimeter.*

| NUMBER OF FILTER. | WATER BACTERIA. |             |            |                |             |            | BACILLUS PRODIGIOSUS. |             |            |                |             |            |
|-------------------|-----------------|-------------|------------|----------------|-------------|------------|-----------------------|-------------|------------|----------------|-------------|------------|
|                   | BEFORE FILLING. |             |            | AFTER FILLING. |             |            | BEFORE FILLING.       |             |            | AFTER FILLING. |             |            |
|                   | Third Day.      | Second Day. | First Day. | First Day.     | Second Day. | Third Day. | Third Day.            | Second Day. | First Day. | First Day.     | Second Day. | Third Day. |
| 33 A, . . . . .   | 13              | 13          | 21         | 72             | 20          | 17         | 0.0                   | 0.0         | 0.0        | 3.0            | 2.0         | 0.8        |
| 38, . . . . .     | 24              | 14          | -          | 40             | 132         | 141        | 1.0                   | 1.0         | -          | 5.0            | 25.0        | 25.0       |
| 42, . . . . .     | 9               | 8           | -          | 109            | 45          | 42         | 0.3                   | 0.3         | -          | 24.0           | 21.0        | 16.0       |
| 43, . . . . .     | 70              | 55          | 103        | 675            | 205         | 241        | 10.0                  | 6.0         | 3.0        | 3.0            | 18.0        | 4.0        |
| 44, . . . . .     | 39              | 31          | 70         | 209            | 321         | 256        | 2.0                   | 4.0         | 3.0        | 9.0            | 34.0        | 12.0       |
| 46, . . . . .     | 53              | 28          | -          | 252            | 201         | 165        | 10.0                  | 5.0         | -          | 66.0           | 53.0        | 36.0       |
| 49, . . . . .     | 26              | -           | 46         | 176            | 69          | 91         | 5.0                   | -           | 13.0       | 69.0           | 16.0        | 25.0       |

In some instances only a very small portion of water, applied after the filter was put in operation after filling from below, appeared during that day as effluent. Under such circumstances the bacteria were lower than on the following day.

Some experiments have been made upon Filter No. 8 A, in which the filter, after scraping, was filled from below with city (filtered) water at a rate not exceeding 1,500,000 gallons per acre daily. The results thus far obtained indicate that no diminution in the bacterial efficiency follows this operation.

## CONCLUSIONS.

From the evidence at hand it appears fair to conclude that—

1. No appreciable diminution in the bacterial efficiency of the experimental filters followed scraping, provided there was no mechanical disturbance of the main body of the sand.

2. Filters may be scraped without interfering with their bacterial efficiency by draining the water slightly below the surface of the sand and, after scraping, slowly filling from the top.

3. Filters may be drained and slowly filled from below, after scraping, without diminishing their bacterial efficiency.

4. When filters are drained and filled quickly from below, after scraping, there is an increase in the number of bacteria in the effluent.

5. When filters are drained and filled rapidly from the top a disturbance of the sand follows in the case of some of the experimental filters, which causes a diminution in the bacterial efficiency.

# THE EFFECT UPON BACTERIAL PURIFICATION OF THE AMOUNT OF LOSS OF HEAD.

In some places abroad it is believed that the bacterial efficiency of a filter decreases as the loss of head increases beyond a certain limit. For this and other reasons several of the most recently constructed water filters in Germany are so arranged that the available head is very much less than the total depth of water and sand; in fact, in some instances the available head is less than 2.5 feet. The Lawrence results obtained in 1892 have been arranged to throw light upon this subject and are presented in the table below. In all cases these filters were scraped when the loss of head equalled the total depth of sand and water; and it was just before scraping, of course, that the loss of head approximated the maximum. The next table shows the average number of bacteria per cubic centimeter in the effluent during the three days before and the three days after scraping each filter, as well as the numbers during the intermediate days, that is, the remaining days of each period between scrapings. Owing to the growth of bacteria in some of the filters during mid-summer (see Annual Report for 1892, page 530) the results are divided into three periods, viz.: spring, summer and fall. It may also be stated that the numbers of bacteria in the effluents during each of the three days before scraping were substantially the same with the exception of a few instances in mid-summer when the bacterial growths occurred.

*Summary of Results showing Uniformity of Bacterial Purification by Water Filters during Periods between Scrapings—1892.*

| NUMBER OF FILTER. | Maximum Loss of Head. Inches. | SPRING (MAY 1 TO JULY 15). |                    |                   | SUMMER (JULY 16 TO AUGUST 31). |                    |                   | FALL (SEPTEMBER 1 TO NOVEMBER 1). |                    |                   | Number of Scrapings. |
|-------------------|-------------------------------|----------------------------|--------------------|-------------------|--------------------------------|--------------------|-------------------|-----------------------------------|--------------------|-------------------|----------------------|
|                   |                               | Intermediate Days.         | Three Days Before. | Three Days After. | Intermediate Days.             | Three Days Before. | Three Days After. | Intermediate Days.                | Three Days Before. | Three Days After. |                      |
| 33 A., .          | 70                            | 44                         | 65                 | 68                | 67                             | 649                | 2,413             | 55                                | 43                 | 47                | 7                    |
| 34 A., .          | 70                            | 20                         | 27                 | 11                | 195                            | 162                | 485               | 28                                | 32                 | 36                | 14                   |
| 35 A., .          | 70                            | 34                         | 23                 | 24                | 22                             | 2,555              | 25                | 99                                | 45                 | 56                | 6                    |
| 36 A., .          | 70                            | 20                         | 26                 | 19                | 708                            | 60                 | 104               | 40                                | 18                 | 32                | 4                    |
| 37, .             | 70                            | 11                         | 27                 | 64                | 95                             | 4,664              | 180               | 44                                | 36                 | 65                | 5                    |
| 38, .             | 35                            | 12                         | 29                 | 104               | 2,104                          | 121                | 223               | 86                                | 46                 | 78                | 8                    |
| 39, .             | 23                            | 68                         | 74                 | 115               | 89                             | 7,455              | 864               | 45                                | 54                 | 87                | 16                   |
| 40, .             | 23                            | 61                         | 45                 | 64                | 435                            | 392                | 186               | 42                                | 39                 | 49                | 10                   |
| 41, .             | 70                            | 26                         | 3                  | 115               | 71                             | 70                 | 60                | 29                                | 37                 | 32                | 7                    |
| Tot's and Av's, . | .                             | 42                         | 36                 | 65                | 415                            | 1,793              | 504               | 52                                | 37                 | 57                | 77                   |
| Total Av., .      | .                             | 47                         | 36                 | 61                | (Spring and Fall.)             |                    |                   | -                                 | -                  | -                 | -                    |

These results show that during the spring and fall there was no diminution in the bacterial efficiency of these experimental filters as the loss of head approached and reached the maximum (total depth of water and sand); neither was there any apparent difference in this regard between those filters which had a maximum loss of head of 70 inches and those in which the maximum loss was less than half of this amount. It will be seen that during midsummer the highest number of bacteria in the effluent in some cases did appear when the loss of head was greatest. This was undoubtedly due to the conditions existing in the filter which favored the continuance of life and growth of certain species of bacteria, and the high numbers occurred just before scraping and when the loss of head was greatest, because the accumulation of organic matter (food) was largest at that time.

The average results obtained from all of the small water filters in 1893 with regard to this point are presented in the table on page 463. These averages contain all results, including those of midsummer, when the abnormal growth of bacteria occurred within the filters. This growth, however, was much less marked than in 1892. The final averages for 1893 confirm the results obtained during the preceding year and show clearly that with these experimental filters, under the existing methods of operation, there is ordinarily no appreciable diminution in the bacterial efficiency caused by increases in loss of head up to 70 inches.

In the case of the continuous Filter No. 8 A (one two-hundredth of an acre in area) there were several occasions, notably December 1 and 29 (see beyond), when the number of bacteria increased in the effluent, just before scraping, and the loss of head reached the total depth of the filter. There was no trap on the outlet pipe of this filter, and the bacteria in the effluent did not increase until the loss of head had practically reached the maximum and when there was not enough pressure on the open gate to cause the prescribed quantity of effluent to pass. Under these circumstances air entered the filter through the outlet pipe, and the water probably filtered through the sand in certain places of least resistance at a relatively high rate. It is believed that these results are very exceptional and caused by the entrance of air from below through the untrapped outlet. It is of importance to note that the bacterial results were normal so long as there was any pressure upon the outlet gate in excess of that necessary for the passage of the prescribed quantity



of water. Furthermore, the outlet was kept trapped at later dates and no increase in the numbers of bacteria in the effluent was found just before scraping, although the scraping was deferred until the filter ran nearly dry.

It is also to be noted that in the case of the Lawrence city filter during January and February (see tables beyond) the number of bacteria in the effluent remained reasonably constant up to February 19, the date when scraping in sections began, although the loss of head increased from 3 to 7.6 feet.

#### THE EFFECT UPON THE BACTERIAL PURIFICATION OF THE METHOD OF APPLICATION OF WATER.

In comparing the efficiency of the intermittent with that of the continuous filters it is to be kept in mind that several different ways have been employed for allowing the entrance of air into the pores of the intermittent water filters. In most cases, up to October 1, 1893, the outlets of the intermittent filters have been untrapped and kept wide open, while the rate of filtration of water has been regulated at the inlet on the surface; these filters have been worked sixteen hours a day on six days in a week and allowed to drain the remainder of the time. Other filters, such as the older ones, No. 18 A and 20 A, also had the outlet untrapped and wide open, but received the contents of a small reservoir which was automatically discharged upon the surface at frequent and regular intervals, days, nights and Sundays. Beginning October 1, 1893, all of the intermittent filters have been operated as follows: at 5 A.M., after draining, the untrapped outlet has been closed and the water turned on at the top, which forces out the air at the surface. When the surface is covered and the air driven out of the pores of the sand (about 7.30 A.M.) the gate on the outlet pipe is opened to give the prescribed rate and the surface kept covered with water. At 9 P.M. the water is shut off at the top and the filter allowed to drain over night. In this method of operation there are two features which are not necessarily a part of intermittent filtration.

I. The actual rate of filtration during the hours the filter was operated was 50 per cent. higher than the average rate for twenty-four hours in order that the yield of effluent in sixteen hours should equal that of the continuous mate in twenty-four hours.

II. The exclusion of air from the pores of the sand by the manner of filling the filters and the resulting disturbance of the surface by the escaping air.

In studying the results obtained from the several pairs of intermittent and continuous filters, which are presented below, the different methods of operation of the intermittent filters are not to be forgotten, and are as follows: up to October 1 and from November 21 to 30 the intermittent filters, Nos. 41, 45, 47 and 48, were operated sixteen hours a day on six days in a week, with the outlet untrapped and wide open and the rate of filtration regulated at the inlet at the surface. During the rest of the period covered by these results the untrapped outlet was closed after draining and water applied at the top; when the surface was covered the outlet was opened to give the prescribed rate.

*Table showing a Comparison of the Number of Bacteria, per Cubic Centimeter, arranged as Weekly Averages, in the Effluents of each Pair of Continuous and Intermittent Filters.*

| NUMBER OF FILTER.   | 33A.                 |                          | 41.                  |                          | 43.                  |                          | 45.                  |                          | 44.                  |                          | 47.                  |                          | 49.                  |                          | 48.                  |                          |
|---------------------|----------------------|--------------------------|----------------------|--------------------------|----------------------|--------------------------|----------------------|--------------------------|----------------------|--------------------------|----------------------|--------------------------|----------------------|--------------------------|----------------------|--------------------------|
| WEEK ENDING — 1893. | CON-TINUOUS.         |                          | INTER-MITTENT.       |                          | CON-TINUOUS.         |                          | INTER-MITTENT.       |                          | CON-TINUOUS.         |                          | INTER-MITTENT.       |                          | CON-TINUOUS.         |                          | INTER-MITTENT.       |                          |
|                     | Water Bac-<br>teria. | Bacillus<br>Prodigiosus. | Water Bac-<br>teria. | Bacillus<br>Prodigiosus. | Water Bac-<br>teria. | Bacillus<br>Prodigiosus. | Water Bac-<br>teria. | Bacillus<br>Prodigiosus. | Water Bac-<br>teria. | Bacillus<br>Prodigiosus. | Water Bac-<br>teria. | Bacillus<br>Prodigiosus. | Water Bac-<br>teria. | Bacillus<br>Prodigiosus. | Water Bac-<br>teria. | Bacillus<br>Prodigiosus. |
| May 13, .           | 10                   | 1.5                      | 44                   | -                        | -                    | -                        | -                    | -                        | -                    | -                        | -                    | -                        | -                    | -                        | -                    | -                        |
| 20, .               | 10                   | 0.3                      | 10                   | 0.5                      | -                    | -                        | -                    | -                        | -                    | -                        | -                    | -                        | -                    | -                        | -                    | -                        |
| 27, .               | 7                    | 5.3                      | 7                    | 2.7                      | 1,339                | 67.0                     | -                    | -                        | (New.)               | 891                      | 74.0                 | -                        | -                    | -                        | -                    | -                        |
| June 3, .           | 10                   | 1.3                      | 10                   | 1.2                      | 541                  | 20.0                     | -                    | -                        | 172                  | 24.0                     | -                    | -                        | -                    | -                        | -                    | -                        |
| 10, .               | 10                   | 0.8                      | 11                   | 2.1                      | 287                  | 3.8                      | -                    | -                        | 118                  | 8.0                      | -                    | -                        | -                    | -                        | -                    | -                        |
| 17, .               | 12                   | 0.6                      | 6                    | 0.2                      | 292                  | -                        | -                    | -                        | 51                   | -                        | -                    | -                        | -                    | -                        | -                    | -                        |
| 24, .               | 6                    | 0.1                      | 11                   | 2.5                      | 225                  | -                        | -                    | -                        | 50                   | -                        | -                    | -                        | -                    | -                        | -                    | -                        |
| July 1, .           | 29                   | 0.8                      | 12                   | 1.3                      | 292                  | -                        | -                    | -                        | 46                   | -                        | -                    | -                        | -                    | -                        | -                    | -                        |
| 8, .                | 15                   | 4.2                      | 17                   | 1.8                      | 140                  | 5.2                      | (New.)               | 23                       | 3.8                  | -                        | -                    | -                        | -                    | -                        | -                    | -                        |
| 15, .               | 48                   | 1.4                      | 30                   | 1.7                      | 63                   | 4.0                      | 1,586                | 92.0                     | 44                   | 6.0                      | -                    | -                        | -                    | -                        | -                    | -                        |
| 22, .               | 23                   | 2.6                      | 40                   | 7.0                      | 38                   | 8.4                      | 279                  | 140.0                    | 30                   | 13.0                     | -                    | -                        | -                    | -                        | -                    | -                        |
| 29, .               | 306                  | 2.2                      | 47                   | 7.0                      | 58                   | 5.2                      | 177                  | 52.0                     | 19                   | 7.5                      | -                    | -                        | -                    | -                        | -                    | -                        |
| Aug. 5, .           | 54                   | 4.7                      | 49                   | 12.3                     | 33                   | 11.2                     | 155                  | 52.0                     | 25                   | 11.5                     | -                    | -                        | -                    | -                        | -                    | -                        |
| 12, .               | 90                   | 1.7                      | 30                   | 4.8                      | 29                   | 5.0                      | 81                   | 19.0                     | 19                   | 2.4                      | -                    | -                        | -                    | -                        | -                    | -                        |
| 19, .               | 51                   | 1.7                      | 32                   | 7.2                      | 23                   | 6.0                      | 62                   | 30.0                     | 40                   | 11.0                     | -                    | -                        | -                    | -                        | -                    | -                        |
| 26, .               | 149                  | 2.7                      | 15                   | 2.7                      | 18                   | 3.6                      | 107                  | 21.0                     | 40                   | 4.8                      | -                    | -                        | -                    | -                        | -                    | -                        |
| Sept. 2, .          | 190                  | 0.3                      | 68                   | 0.6                      | 19                   | 0.4                      | 66                   | 3.0                      | 22                   | 0.3                      | -                    | -                        | -                    | -                        | -                    | -                        |
| 9, .                | 26                   | 1.5                      | 26                   | 1.3                      | 10                   | 0.6                      | 185                  | 7.6                      | 4                    | 0.5 (New.)               | -                    | -                        | (New.)               | -                        | (New.)               | -                        |
| 16, .               | 30                   | 3.7                      | 17                   | 1.6                      | 11                   | 2.4                      | 153                  | 9.5                      | 9                    | 1.0                      | 1,630                | 371.0                    | 647                  | 46.                      | 1,912                | 244.2                    |
| 23, .               | 20                   | 1.0                      | 51                   | 9.0                      | 15                   | 1.3                      | 129                  | 6.8                      | 8                    | 0.8                      | 1,233                | 78.3                     | 236                  | 1.8                      | 1,151                | 99.5                     |
| 30, .               | 120                  | 1.4                      | 95                   | 1.9                      | 171                  | 4.5                      | 2,143                | 16.2                     | 169                  | 2.5                      | 3,671                | 55.0                     | 111                  | 4.7                      | 6,547                | 51.5                     |
| Oct. 7, .           | 64                   | 0.8                      | 34                   | 1.1                      | 45                   | 1.3                      | 1,186                | 28.5                     | 22                   | 0.3                      | 1,436                | 18.5                     | 186                  | 3.3                      | 843                  | 62.0                     |
| 14, .               | 46                   | 0.1                      | 20                   | 0.4                      | 30                   | 0.9                      | 188                  | 8.2                      | 15                   | 0.5                      | 607                  | 24.0                     | 87                   | 3.0                      | 885                  | 42.0                     |
| 21, .               | 24                   | 0.0                      | 11                   | 0.2                      | 24                   | 0.6                      | 114                  | 9.0                      | 14                   | 0.5                      | 274                  | 15.0                     | 87                   | 9.0                      | 320                  | 25.0                     |
| 28, .               | 26                   | 0.1                      | 14                   | 0.5                      | 94                   | 26.0                     | 56                   | 8.0                      | 37                   | 6.5                      | 71                   | 13.0                     | 85                   | 11.0                     | 81                   | 14.0                     |
| Nov. 4, .           | 17                   | 0.0                      | 10                   | 0.5                      | 35                   | 13.0                     | 63                   | 11.0                     | 27                   | 10.0                     | 62                   | 24.0                     | 56                   | 18.0                     | 83                   | 27.0                     |
| 11, .               | 20                   | 0.6                      | 11                   | 0.5                      | 71                   | 9.0                      | 107                  | 12.0                     | 57                   | 8.0                      | 180                  | 25.0                     | 93                   | 9.0                      | 182                  | 28.0                     |
| 18, .               | 16                   | 0.6                      | 12                   | 0.3                      | 45                   | 12.0                     | 38                   | 7.5                      | 42                   | 7.0                      | 154                  | 30.5                     | 86                   | 26.0                     | 133                  | 33.0                     |
| 25, .               | 27                   | 0.9                      | 7                    | 0.0                      | 225                  | 7.0                      | 105                  | 14.0                     | 154                  | 11.0                     | 541                  | 47.0                     | 39                   | 3.2                      | 93                   | 16.0                     |
| Dec. 2, .           | 64                   | 2.4                      | 10                   | 0.0                      | 234                  | 13.4                     | 286                  | 18.0                     | 201                  | 14.0                     | 276                  | 25.0                     | 87                   | 6.0                      | 128                  | 10.0                     |

The results obtained from Filters Nos. 3 B and 8 A are instructive in this connection; the summarized and detailed results are given in tables which may be found beyond.

The results at hand, obtained from the several pairs of continuous and intermittent filters, show —

1. That in the case of the filters of very fine sand (in which there is a saturated layer of considerable depth) the bacterial efficiency was substantially the same by each method employed in the application of water during the greater part of the period, but during mid-summer (July 24 to September 2) the continuous filter allowed a few more of the hardy water bacteria, but not of *B. prodigiosus*, to pass through.

2. That with filters of coarser sands, operated at comparatively high rates, the continuous filters were ordinarily more efficient in removing bacteria than the intermittent filters under the existing methods of operation. The reason of this is that the actual rate of flow was lower and more uniform and there was no mechanical disturbance of the sand as was the case during the greater part of the period with the intermittent filters, owing to the manner of filling and driving out the air at the surface.

#### CHEMICAL PURIFICATION OF WATER BY FILTRATION.

The results of the chemical analyses, from May to November, inclusive, indicate that on an average 45 per cent. of the total albuminoid ammonia, of which 15 to 20 per cent. is usually in suspension, in the applied river water appeared in the effluents. The total albuminoid ammonia of the river water which appears in the effluents ordinarily ranges from 35 to 60 per cent.; the extremes are 30 and 70 per cent.

A comparison of the efficiency with regard to the removal of organic matter of filtration under different conditions is presented below. For details regarding methods of operation and results of analyses see pages beginning with 488.

*Table showing Per Cent. of Albuminoid Ammonia in Applied Water which appeared in the several Effluents at Different Rates of Filtration.*

[Rates are expressed in million gallons per acre daily.]

| NUMBER OF FILTER. | Method of Operation. | Effective Size of Sand Grain. — Millimeter. | MAY.  |                     | JUNE. |                     | JULY. |                     | AUG.  |                     | SEPT. |                     | OCT.  |                     | NOV.  |                     |
|-------------------|----------------------|---------------------------------------------|-------|---------------------|-------|---------------------|-------|---------------------|-------|---------------------|-------|---------------------|-------|---------------------|-------|---------------------|
|                   |                      |                                             | Rate. | Albuminoid Ammonia. | Rate. | Albuminoid Ammonia. | Rate. | Albuminoid Ammonia. | Rate. | Albuminoid Ammonia. | Rate. | Albuminoid Ammonia. | Rate. | Albuminoid Ammonia. | Rate. | Albuminoid Ammonia. |
| 18 A.             | Intermittent.        | .48                                         | 1.5   | 55.                 | 2.3   | 42.                 | 1.7   | 42.                 | 1.9   | 36.                 | 1.7   | 57.                 | 1.6   | 57.                 | 1.8   | 53.                 |
| 33 A.             | Continuous.          | .14                                         | 1.7   | 48.                 | 1.7   | 39.                 | 1.9   | 37.                 | 2.7   | 37.                 | 1.9   | 46.                 | 1.9   | 42.                 | 2.8   | 46.                 |
| 34 A.             | Continuous.          | .09                                         | 1.6   | 47.                 | 1.4   | 47.                 | 1.9   | 40.                 | 2.3   | 35.                 | -     | -                   | -     | -                   | -     | -                   |
| 35 A.             | Intermittent.        | .20                                         | 1.4   | 49.                 | 1.2   | 39.                 | 1.7   | 37.                 | 3.0   | 34.                 | -     | -                   | -     | -                   | -     | -                   |
| 36 A.             | Continuous.          | .20                                         | 2.0   | 51.                 | 2.0   | 40.                 | 3.0   | 37.                 | 1.7   | 35.                 | 1.2   | 43.                 | -     | -                   | -     | -                   |
| 37.               | Intermittent.        | .20                                         | 2.0   | 51.                 | 2.0   | 40.                 | 3.0   | 37.                 | 1.7   | 35.                 | 1.2   | 43.                 | -     | -                   | -     | -                   |
| 37.               | Continuous.          | .20                                         | 1.7   | 47.                 | 3.4   | 44.                 | -     | -                   | -     | -                   | -     | -                   | -     | -                   | -     | -                   |
| 38.               | Continuous.          | .20                                         | 1.9   | 53.                 | 1.7   | 40.                 | 1.9   | 37.                 | 2.5   | 40.                 | 1.9   | 39.                 | 2.0   | 48.                 | 3.4   | 53.                 |
| 39.               | Continuous.          | .20                                         | 2.0   | 53.                 | 1.6   | 41.                 | 1.5   | 55.                 | 1.7   | 46.                 | -     | -                   | -     | -                   | -     | -                   |
| 39.               | Intermittent.        | .20                                         | 2.0   | 53.                 | 1.6   | 41.                 | 1.5   | 55.                 | 1.7   | 46.                 | -     | -                   | -     | -                   | -     | -                   |
| 41.               | Intermittent.        | .14                                         | 2.0   | 48.                 | 1.5   | 47.                 | 2.0   | 41.                 | 1.9   | 37.                 | 1.9   | 51.                 | 1.8   | 41.                 | 1.6   | 49.                 |
| 42.               | Continuous.          | .20                                         | 1.9   | 51.                 | 1.7   | 43.                 | 1.9   | 40.                 | 1.9   | 32.                 | 1.8   | 47.                 | 2.0   | 50.                 | 1.9   | 47.                 |
| 43.               | Continuous.          | .26                                         | 2.2   | 55.                 | 3.9   | 40.                 | 2.8   | 43.                 | 4.3   | 37.                 | 4.5   | 55.                 | 4.8   | 47.                 | 7.6   | 51.                 |
| 44.               | Continuous.          | .29                                         | 2.2   | 60.                 | 2.8   | 48.                 | 2.8   | 42.                 | 4.3   | 37.                 | 4.7   | 57.                 | 5.8   | 46.                 | 7.6   | 52.                 |
| 45.               | Intermittent.        | .23                                         | -     | -                   | -     | -                   | 1.5   | 51.                 | 1.9   | 40.                 | 1.7   | 72.                 | 1.8   | 48.                 | 3.6   | 52.                 |
| 46.               | Continuous.          | .29                                         | -     | -                   | -     | -                   | -     | -                   | -     | -                   | 1.9   | 63.                 | 2.3   | 44.                 | 3.6   | 54.                 |
| 47.               | Intermittent.        | .29                                         | -     | -                   | -     | -                   | -     | -                   | -     | -                   | 1.7   | 70.                 | 1.8   | 56.                 | 3.6   | 59.                 |
| 48.               | Intermittent.        | .38                                         | -     | -                   | -     | -                   | -     | -                   | -     | -                   | 1.8   | 67.                 | 1.8   | 55.                 | 2.9   | 57.                 |
| 49.               | Continuous.          | .38                                         | -     | -                   | -     | -                   | -     | -                   | -     | -                   | 2.1   | 69.                 | 2.6   | 42.                 | 5.8   | 57.                 |

In filters of these materials, and in which nitrification is well established, the rate of filtration, within these limits, appears to exert very little or no influence upon the removal of organic matter.

### *Effect of Size of Sand Grain.*

The results obtained in October and November were selected for the following table because they were obtained under comparable conditions.

*I. Continuous Filters.*

| NUMBER OF FILTER. | Effective Size of Sand Grain.<br>—<br>Millimeter. | Average Rate of Filtration.<br>—<br>Million Gallons per Acre Daily. | Per Cent. of Albuminoid Ammonia in Applied Water which Appeared in Effluents. | Per Cent. which Oxygen Consumed in Effluents was of that in Applied Water. |
|-------------------|---------------------------------------------------|---------------------------------------------------------------------|-------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| 33 A, . . . . .   | .14                                               | 2.4                                                                 | 44.                                                                           | 76.                                                                        |
| 38, . . . . .     | .20                                               | 2.7                                                                 | 50.                                                                           | 82.                                                                        |
| 43, . . . . .     | .26                                               | 6.2                                                                 | 49.                                                                           | 78.                                                                        |
| 44, . . . . .     | .29                                               | 6.7                                                                 | 50.                                                                           | 80.                                                                        |
| 49, . . . . .     | .38                                               | 4.0                                                                 | 49.                                                                           | 78.                                                                        |

*II. Intermittent Filters.*

|                 |     |     |     |     |
|-----------------|-----|-----|-----|-----|
| 41, . . . . .   | .14 | 1.7 | 45. | 78. |
| 45, . . . . .   | .23 | 2.7 | 50. | 76. |
| 47, . . . . .   | .29 | 2.7 | 57. | 80. |
| 48, . . . . .   | .38 | 2.4 | 56. | 80. |
| 18 A, . . . . . | .48 | 1.7 | 55. | 91. |

In continuous and intermittent filtration, through materials of these limits in effective size and under the given conditions of operation, there was no marked difference in the amounts of organic matter removed from the applied water by the filters which were filled with sand of different effective sizes.

*Effect of Depth of Material.*

| NUMBER OF FILTER. | Effective Size of Sand Grain.<br>—<br>Millimeter. | Depth in Inches. | Average Rate of Filtration.<br>—<br>Million Gallons per Acre Daily. | Period.<br>1893. | Per Cent. of Albuminoid Ammonia in Applied Water which Appeared in Effluents. | Per Cent. which Oxygen Consumed in Effluents was of that in Applied Water. |
|-------------------|---------------------------------------------------|------------------|---------------------------------------------------------------------|------------------|-------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| 37, . . . . .     | .20                                               | 55               | 2.6                                                                 | May and June.    | 45.                                                                           | 81.                                                                        |
| 38, . . . . .     | .20                                               | 20               | 1.8                                                                 | May and June.    | 46.                                                                           | 81.                                                                        |
| 39, . . . . .     | .20                                               | 1                | 1.8                                                                 | May and June.    | 47.                                                                           | 78.                                                                        |
| 42, . . . . .     | .20                                               | 10               | 1.8                                                                 | May and June.    | 47.                                                                           | 86.                                                                        |
| 44, . . . . .     | .29                                               | 60               | 2.6                                                                 | May and June.    | 54.                                                                           | 74.                                                                        |
| 46, . . . . .     | .29                                               | 12               | 2.9                                                                 | Oct. and Nov.    | 49.                                                                           | 80.                                                                        |
| 44, . . . . .     | .29                                               | 60               | 6.7                                                                 | Oct. and Nov.    | 49.                                                                           | 80.                                                                        |

There was practically no difference in the power of removal of organic matter from the river water by the several filters of each series. It is to be remembered that in addition to the sand each filter contained 5 inches of underdrains.

In 1892 the results obtained from the first series of filters indicated that the deeper were somewhat more effective than the shallower filters. It is believed that the 1893 data are fairer because they were obtained under strictly comparable conditions.

*Effect of the Method of Application of Water.*

In the Annual Report of the Board for 1892 (page 466) it was shown that there was practically the same amount of free and albuminoid ammonia in the effluents of the continuous and the intermittent filters. The nitrates, however, were higher in the effluents of the latter.

It is to be again stated that it is necessary to consider the different methods practised in running the intermittent filters, and the peculiar features of each. In this connection see page 472.

Nearly all of the samples of effluents of intermittent filters analyzed during 1892 were collected within two or three hours of the time when the effluent began to flow after the interval of rest. The results of the analyses of more extended series of samples collected during different hours of the day in 1893 show that such samples in a majority of cases are not representative with respect to the nitrates in the case of the effluents of intermittent filters under the existing method of operation. The variations are shown by the representative analysis given below of samples from No. 41, taken on September 20. This filter was operated sixteen hours a day with the faucet below always open and untrapped, the rate regulated at the top and the filter allowed to drain during the remaining hours.

[Parts per 100,000.]

| EFFLUENT OF<br>FILTER NUMBER | Hour.      | Gallons<br>passed<br>since in-<br>terval of<br>Rest. | Color. | AMMONIA. |                  | Chlo-<br>rine. | NITROGEN AS |           | Oxygen<br>Con-<br>sumed. |
|------------------------------|------------|------------------------------------------------------|--------|----------|------------------|----------------|-------------|-----------|--------------------------|
|                              |            |                                                      |        | Free.    | Albu-<br>minoid. |                | Nitrates.   | Nitrites. |                          |
| 41, . . . .                  | 8.52 A.M.  | 1                                                    | .18    | .0010    | .0064            | .22            | .0290       | .0000     | .21                      |
| 41, . . . .                  | 9.12 A.M.  | 3                                                    | .18    | .0012    | .0076            | .22            | .0330       | .0000     | .21                      |
| 41, . . . .                  | 11.20 P.M. | 23                                                   | .19    | .0014    | .0092            | .22            | .0310       | .0000     | .22                      |
| 41, . . . .                  | 1.30 P.M.  | 40                                                   | .20    | .0020    | .0106            | .22            | .0290       | .0000     | .22                      |
| 41, . . . .                  | 3.06 P.M.  | 52                                                   | .20    | .0022    | .0100            | .22            | .0240       | .0000     | .22                      |
| 41, . . . .                  | 5.06 P.M.  | 70                                                   | .20    | .0022    | .0092            | .22            | .0230       | .0000     | .23                      |
| 33 A, . . .                  | 9.14 A.M.  | -                                                    | .22    | .0018    | .0090            | .22            | .0280       | .0000     | .24                      |
| Applied water,               | 10.25 A.M. | -                                                    | .35    | .0054    | .0168            | .22            | .0150       | .0000     | .42                      |

While it is seen that there is a marked variation during the day in the nitrates of the effluent of this intermittent filter under these conditions of operation there is, under ordinary circumstances, substantially no change in the effluent of continuous filters. This is

shown by the following table in which are given the average results of three sets of samples collected at 9 A.M. and 3 P.M. from the effluent of No. 33 A the mate of No. 41.

[Parts per 100,000.]

| Hour.           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. |
|-----------------|--------|----------|-------------|-----------|-------------|-----------|------------------|
|                 |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |
| 9 A.M., . . . . | .27    | .0017    | .0110       | .20       | .0250       | .0000     | .29              |
| 3 P.M., . . . . | .28    | .0019    | .0110       | .20       | .0250       | .0000     | .31              |

In the table below are given the average results obtained in October and November from the effluent of four pairs of continuous and intermittent filters. The intermittent filters were operated sixteen hours daily, six days in a week, with the outlets untrapped and closed while the filters, after draining, were filled with water from the top. After the air was driven from the pores and the surface covered the outlet gate was opened to give the prescribed rate of flow. Samples were collected at different hours during the day from the effluent of the intermittent filters, and it is believed that the results below, which correspond to the results of the analyses of samples collected four to six hours after the period of rest, are representative for the period.

*Continuous Filters.*

| NUMBER OF FILTER. | Effective Size of Sand Grain.<br>Millimeter. | Average Rate of Filtration.<br>Million Gallons per Acre Daily. | Per Cent. of Albuminoid Ammonia in Applied Water which appeared in Effluent. | Per Cent. of Oxygen Consumed in Applied Water which Appeared in Effluent. | Nitrogen as Nitrates.<br>(Parts per 100,000.) |
|-------------------|----------------------------------------------|----------------------------------------------------------------|------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------|
| 33 A, . . . .     | .14                                          | 2.4                                                            | 44.                                                                          | 76.                                                                       | .0240                                         |
| 43, . . . .       | .26                                          | 6.2                                                            | 49.                                                                          | 78.                                                                       | .0240                                         |
| 44, . . . .       | .29                                          | 6.7                                                            | 49.                                                                          | 80.                                                                       | .0240                                         |
| 49, . . . .       | .38                                          | 4.0                                                            | 49.                                                                          | 78.                                                                       | .0220                                         |

*Intermittent Filters.*

|             |     |     |     |     |       |
|-------------|-----|-----|-----|-----|-------|
| 41, . . . . | .14 | 1.7 | 45. | 78. | .0230 |
| 45, . . . . | .23 | 2.7 | 50. | 76. | .0220 |
| 47, . . . . | .29 | 2.7 | 50. | 76. | .0200 |
| 48, . . . . | .38 | 2.4 | 57. | 80. | .0220 |

These results indicate that during these months there was practically no difference in the average chemical purification effected by the continuous and intermittent filters under existing conditions of operation. The most substantial confirmation of this is that Filters Nos. 33 A and 41, a pair which had been operated over a year and a half, contained substantially the same amount of organic nitrogen in the sand on December 8, at the end of the period covered by the analyses presented above. The amount of organic matter in the sand removed by scraping was also the same (see tables, pages 484-486).

During the period of rest (8 hours) in the intermittent filters for the greater part of the year there was increased nitrification of the organic matter stored in the sand; when water was again applied the nitrates formed during the period of rest were gradually washed out, giving a higher quantity for several hours than is found in the effluents of continuous filters. After a time, depending upon the rate of flow, these high nitrates fall to the normal. The reason that the continuous filtration of water is successful, while with sewage this method is a failure, is that the applied water contains dissolved oxygen and, as will be seen from the table (page 482), the dissolved oxygen in the effluents of the continuous filters has never been found wanting. It is to be remembered in this connection that it was shown in the Special Report upon Purification of Sewage and Water, 1890, page 730, that a small amount of oxygen (1 to 3 per cent.) in the air of the filter was effective, provided the air was changed so often that some oxygen was always present at every point.

The results presented above are for the fall months, and it is believed that they are representative for the spring months also. But the evidence at hand indicates that the results are different in the warmest summer weather and in the severest winter weather.

In mid-summer the conditions for nitrification appear to be the most favorable both in continuous and intermittent filters but it is more marked in the case of the latter. This is brought out by the following table of monthly averages of effluents of Filters Nos. 33 A and 41 and by a series of analyses of the effluents. It will be noted that high nitrates in the effluent of the intermittent filter (outlet untrapped and kept wide open) were found when the quantity of effluent yielded after the period of rest exceeded the quantity of water held in the pores of the sand. In the case of the continuous as well as of the intermittent filter the effluent contained at times



more nitrogen than the applied water, showing a removal of organic matter stored in the sand. In most instances the samples from No. 41 were collected at 2 P. M. when series of samples were not taken.

*Monthly Averages of Chemical Analyses.*

[Parts per 100,000.]

*June, 1893.*

|                              | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. |
|------------------------------|--------|----------|-------------|-----------|-------------|-----------|------------------|
|                              |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |
| Effluent of Filter No. 33 A, | .28    | .0011    | .0087       | .15       | .0335       | .0000     | .29              |
| Effluent of Filter No. 41, . | .30    | .0014    | .0104       | .16       | .0255       | .0000     | .30              |
| Applied water, . . .         | .37    | .0076    | .0222       | .17       | .0180       | .0000     | .40              |

*July, 1893.*

|                              |     |       |       |     |       |       |     |
|------------------------------|-----|-------|-------|-----|-------|-------|-----|
| Effluent of Filter No. 33 A, | .22 | .0015 | .0096 | .19 | .0347 | .0000 | .21 |
| Effluent of Filter No. 41, . | .21 | .0027 | .0105 | .20 | .0407 | .0000 | .22 |
| Applied water, . . .         | .36 | .0100 | .0259 | .19 | .0200 | .0002 | .34 |

*August, 1893.*

|                              |     |       |       |     |       |       |     |
|------------------------------|-----|-------|-------|-----|-------|-------|-----|
| Effluent of Filter No. 33 A, | .17 | .0023 | .0098 | .20 | .0297 | .0013 | .16 |
| Effluent of Filter No. 41, . | .17 | .0018 | .0097 | .20 | .0364 | .0000 | .16 |
| Applied water, . . .         | .29 | .0103 | .0263 | .20 | .0180 | .0001 | .28 |

*Results of a Series of Chemical Analyses on August 22, 1893.*

[Parts per 100,000.]

|                                           | Hour.      | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. |
|-------------------------------------------|------------|--------|----------|-------------|-----------|-------------|-----------|------------------|
|                                           |            |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |
| Effluent of Filter No. 41 (intermittent). | 9.50 A.M.  | .18    | .0032    | .0088       | .21       | .0490       | .0008     | .12              |
|                                           | 1.25 P.M.  | .19    | .0032    | .0116       | .21       | .0530       | .0000     | .15              |
|                                           | 3.12 P.M.  | .19    | .0014    | .0086       | .21       | .0520       | .0000     | .14              |
| Effluent of Filter No. 33 A (continuous). | 10.20 A.M. | .19    | .0016    | .0106       | .21       | .0330       | .0000     | .15              |
|                                           | 2.17 P.M.  | .19    | .0012    | .0118       | .21       | .0290       | .0014     | .17              |
| Applied water, . . . .                    | 2.05 P.M.  | .28    | .0070    | .0280       | .21       | .0190       | .0004     | .29              |

The above results obtained in the warmest weather indicate with regard to nitrification that, under the existing conditions of operation, the advantage lies with the intermittent filters. During the

winter months, with another pair of filters, Nos. 3 B and 8 A, the advantage lay with the continuous filter, as shown by the following table of monthly averages. No. 3 B was operated intermittently, — drained 8 hours daily, outlet untrapped and closed while filling; No. 8 A, continuously. The analyses were made of mixed samples collected in portions at different hours during the day and are believed to be representative.

*Monthly Averages of Chemical Analyses.*

[Parts per 100,000.]

*December, 1893.*

|                             | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. |
|-----------------------------|--------|----------|-------------|-----------|-------------|-----------|------------------|
|                             |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |
| Effluent of Filter No. 3 B, | .88    | .0029    | .0121       | .20       | .0190       | .0000     | .42              |
| Effluent of Filter No. 8 A, | .37    | .0021    | .0117       | .20       | .0230       | .0000     | .30              |
| Applied water, . . .        | .44    | .0057    | .0177       | .20       | .0150       | .0000     | .49              |

*January, 1894.*

|                             |     |       |       |     |       |       |     |
|-----------------------------|-----|-------|-------|-----|-------|-------|-----|
| Effluent of Filter No. 3 B, | .38 | .0021 | .0117 | .21 | .0250 | .0000 | .35 |
| Effluent of Filter No. 8 A, | .37 | .0016 | .0115 | .21 | .0300 | .0000 | .35 |
| Applied water, . . .        | .43 | .0055 | .0164 | .21 | .0150 | .0001 | .41 |

*February, 1894.*

|                             |     |       |       |     |       |       |     |
|-----------------------------|-----|-------|-------|-----|-------|-------|-----|
| Effluent of Filter No. 3 B, | .34 | .0018 | .0107 | .22 | .0270 | .0000 | .36 |
| Effluent of Filter No. 8 A, | .32 | .0017 | .0106 | .22 | .0310 | .0000 | .33 |
| Applied water, . . .        | .40 | .0068 | .0160 | .22 | .0180 | .0001 | .42 |

*March, 1894.*

|                             |     |       |       |     |       |       |     |
|-----------------------------|-----|-------|-------|-----|-------|-------|-----|
| Effluent of Filter No. 3 B, | .40 | .0014 | .0096 | .15 | .0180 | .0000 | .35 |
| Effluent of Filter No. 8 A, | .39 | .0016 | .0102 | .15 | .0180 | .0000 | .34 |
| Applied water, . . .        | .47 | .0040 | .0193 | .15 | .0180 | .0001 | .46 |

The differences in nitrification were most marked in January and February and disappeared in March. The reason of this is not yet fully understood, but it is possible that the daily exposure of the surface of No. 3 B where most of the organic matter is stored, to the cold atmosphere and the occasional formation of frost, may have interfered with the bacterial activity necessary for nitrification. It is

significant that series of samples taken at frequent intervals during the day from the effluent of No. 3 B showed no marked variations in amount of nitrates during the cold weather, but in April the series were similar to those obtained from No. 41 on September 20, 1893, and which were presented on page 477.

While considerable light has been obtained upon this subject it is still necessary to have additional data before we can draw final conclusions as to the relative merits of the two methods as well as to the best way of operating a filter intermittently.

### *Dissolved Oxygen in the Effluents.*

In the table below is given the average amount of dissolved oxygen in the applied river water and in the effluents of the several filters. In no case was an absence of oxygen noted in the effluents of continuous filters. The effluents of the intermittent filters contained much more oxygen than did the effluents of continuous filters, and during midsummer the amount was in excess of that in the applied water. The analyses were made about four hours after the expiration of the period of rest in the intermittent filters, and it is probable that the quantity became less as the filter continued in operation.

*Per Cent. which the Oxygen dissolved in the Applied Water and Effluents was of that necessary for Saturation at actual Temperatures.*

| DATE—<br>1893. | In<br>Applied<br>Water. | IN EFFLUENTS FROM FILTERS NUMBER— |     |     |      |     |     |     |     |      |     |      |     |     |     |     |      |     |  |
|----------------|-------------------------|-----------------------------------|-----|-----|------|-----|-----|-----|-----|------|-----|------|-----|-----|-----|-----|------|-----|--|
|                |                         | 18A                               | 33A | 34A | 35A  | 36A | 37  | 38  | 39  | 41   | 42  | 43   | 44  | 45  | 46  | 47  | 48   | 49  |  |
| January, .     | 93.                     | 98.                               | 79. | 73. | 96.  | 69. | 70. | 79. | 79. | 99.  | 85. | -    | -   | -   | -   | -   | -    | -   |  |
| February, .    | 96.                     | 98.                               | 71. | 74. | 74.  | 65. | 72. | 78. | 86. | 99.  | 80. | -    | -   | -   | -   | -   | -    | -   |  |
| March, .       | 91.                     | 98.                               | 69. | 80. | 100. | 66. | 75. | 82. | 84. | 100. | 85. | -    | -   | -   | -   | -   | -    | -   |  |
| April, . .     | 100.                    | 100.                              | 76. | 75. | 94.  | 86. | 69. | 73. | 85. | 95.  | 85. | -    | -   | -   | -   | -   | -    | -   |  |
| May, . .       | 86.                     | 97.                               | 55. | 65. | 91.  | 71. | 56. | 68. | 50. | 89.  | 74. | 100. | 93. | -   | -   | -   | -    | -   |  |
| June, . .      | 75.                     | 91.                               | 38. | 54. | 84.  | 64. | 62. | 43. | 38. | 51.  | 63. | 74.  | 75. | -   | -   | -   | -    | -   |  |
| July, . .      | 52.                     | 93.                               | 8.  | 22. | 89.  | 15. | -   | 21. | 62. | 91.  | 11. | 29.  | 38. | 97. | -   | -   | -    | -   |  |
| August, .      | 69.                     | 92.                               | 12. | 18. | 50.  | 86. | -   | 27. | 55. | 79.  | 42. | 38.  | 59. | 95. | 55. | -   | -    | -   |  |
| September, .   | 81.                     | 89.                               | 31. | 38. | -    | -   | -   | 60. | -   | 86.  | 56. | 49.  | 46. | 93. | 49. | 99. | 99.  | 69. |  |
| October, .     | 86.                     | 96.                               | 54. | -   | -    | -   | -   | 47. | -   | 94.  | 54. | 60.  | 71. | 93. | 57. | 99. | 100. | 61. |  |
| November, .    | 95.                     | 100.                              | 81. | -   | -    | -   | -   | 83. | -   | 93.  | 81. | 81.  | 80. | 97. | 81. | 97. | 98.  | 88. |  |
| December, .    | 98.                     | 100.                              | 87. | -   | -    | -   | -   | 82. | -   | 96.  | 82. | 86.  | 83. | 98. | 85. | 95. | 100. | 89. |  |

## THE REMOVAL OF COLOR FROM WATER BY FILTRATION.

The per cent. of color of the applied water which appeared in the effluents of those filters started in 1892 was shown in the Annual Report for that year to be 55, on an average, after there had been filtered 400,000,000 gallons of water per acre. In 1893, after 800,000,000 gallons per acre had been filtered, the average amount of color in the effluents was 65 per cent. of that in the applied water.

The filter two feet deep (No. 38) was as efficient as those five feet deep.

The filters constructed in 1893 contained sand from Gale's Hill, a different source from that used for the earlier filters. This sand was also used for the Lawrence city filter. While in the earlier filters it was found that the sand was most effective in removing color when new, the sand from Gale's Hill removed practically none at first but gradually acquired this power, although apparently to a somewhat less extent than was possessed by the sand used in 1892 for filling filters.

The mineral analyses of the two sands are as follows:—

No. 38 (1892) sand contained 98.70 per cent. of material insoluble in strong sulphuric acid kept at the boiling temperature for two hours; 0.75 per cent. of alumina; 0.30 per cent. oxide of iron and 0.02 per cent. oxide of manganese.

Gale's Hill (1893) sand contained 97.70 per cent. of material insoluble in strong sulphuric acid kept at the boiling temperature for two hours; 0.96 per cent. of alumina; 0.54 per cent. oxide of iron and 0.13 per cent. oxide of manganese.

# NUMBER OF BACTERIA AND AMOUNT OF NITROGEN FOUND IN THE SAND OF THE SEVERAL WATER FILTERS, DECEMBER 8, 1893.

On this date, after the filters had drained twenty-four hours, numerous samples of sand at different depths were taken from each filter and analyzed chemically and bacterially, with results as follows:—

| NUMBER OF FILTER. | Depth. (Inches.) | Method of Operation. | Length of Time in Operation. | Million Gallons per Acre Filtered to Date. | Average Number of Bacteria in Sand per Gram. | Original Nitrogen in Sand. (Parts per 100,000) | Average Increase of Nitrogen in Sand.* (Parts per 100,000.) |
|-------------------|------------------|----------------------|------------------------------|--------------------------------------------|----------------------------------------------|------------------------------------------------|-------------------------------------------------------------|
| 18 A, .           | 60               | Intermittent.        | 4 years, 2 months.           | 1,637                                      | 78,000                                       | 1.0                                            | 2.90                                                        |
| 38 A, .           | 60               | Continuous.          | 1 year, 7 months.            | 1,138                                      | 32,200                                       | 0.8                                            | 1.34                                                        |
| 38, .             | 24               | Continuous.          | 1 year, 7 months.            | 1,092                                      | 213,500                                      | 1.3                                            | 2.97                                                        |
| 41, .             | 60               | Intermittent.        | 1 year, 7 months.            | 948                                        | 37,000                                       | 0.8                                            | 1.36                                                        |
| 42, .             | 12               | Continuous.          | 1 year, 1 month.             | 731                                        | 120,400                                      | 1.3                                            | 3.78                                                        |
| 43, .             | 60               | Continuous.          | 7 months.                    | 907                                        | 136,600                                      | 0.8                                            | 1.12                                                        |
| 44, .             | 60               | Continuous.          | 7 months.                    | 923                                        | 201,500                                      | 0.8                                            | 1.47                                                        |
| 45, .             | 60               | Intermittent.        | 5 months.                    | 349                                        | 62,600                                       | 0.8                                            | 1.26                                                        |
| 46, .             | 12               | Continuous.          | 4 months.                    | 237                                        | 201,600                                      | 0.8                                            | 2.53                                                        |
| 47, .             | 60               | Intermittent.        | 3 months.                    | 241                                        | 93,500                                       | 0.8                                            | 1.30                                                        |
| 48, .             | 60               | Intermittent.        | 3 months.                    | 201                                        | 93,500                                       | 0.8                                            | 0.46                                                        |
| 49, .             | 60               | Continuous.          | 3 months.                    | 323                                        | 51,500                                       | 0.8                                            | 1.34                                                        |

\* The organic nitrogen was calculated as  $\frac{1}{4}$  of the albuminoid ammonia doubled.

Upon dividing the deep filters into two classes, according to the method of application of water, and summarizing the data, it is found that the intermittent filters contained 108 bacteria per gram and an increase in nitrogen of .0021 part per 100,000 for each million gallons of water filtered per acre; while for the continuous filters these figures become 122 and .0016, respectively. It is probable that somewhat different results would be obtained in mid-summer.

In the next tables the results of the analyses of the sand from the several filters are presented with greater detail. It is to be stated that the method followed until September, 1893, of scraping the filters and not replacing the sand removed, until the depth was decreased 6 to 12 inches, caused greater irregularities than would have been the case if the sand removed had always been replaced with clean material at the time of scraping.

*Number of Bacteria per Gram found in the Sand at Different Depths, Dec. 8, 1893.*

| NUMBER OF FILTER.         | 18 A.     | 33 A.    | 38.       | 41.       | 43.       | 43.       |
|---------------------------|-----------|----------|-----------|-----------|-----------|-----------|
| Date when last scraped, . | Oct. 9.   | Nov. 23. | Dec. 4.   | Dec. 7.   | Dec. 2.   | Dec. 7.   |
| Upper quarter-inch, . . . | 1,570,000 | 767,000  | 3,430,000 | 1,750,000 | 1,750,000 | 9,300,000 |
| Upper inch, . . . . .     | 1,350,000 | 536,000  | 2,675,500 | 1,046,800 | 1,047,500 | 5,238,100 |
| Upper six inches, . . .   | 430,000   | 162,900  | 731,100   | 231,100   | 223,600   | 1,007,000 |
| Upper foot, . . . . .     | 267,000   | 108,000  | 309,300   | 141,800   | 130,400   | 576,900   |
| Second foot, . . . . .    | 73,000    | 19,300   | 57,800    | 22,500    | -         | 55,700    |
| Third foot, . . . . .     | 27,000    | 11,500   | -         | 13,500    | -         | 10,300    |
| Fourth foot, . . . . .    | 13,000    | 11,500   | -         | 3,700     | -         | 18,100    |
| Fifth foot, . . . . .     | 10,800    | -        | -         | -         | -         | 22,200    |

*Number of Bacteria per Gram found in the Sand at Different Depths, Dec. 8, 1893 — Concluded.*

| NUMBER OF FILTER.         | 44.       | 45.       | 46.       | 47.       | 48.       | 49.     |
|---------------------------|-----------|-----------|-----------|-----------|-----------|---------|
| Date when last scraped, . | Dec. 7.   | Dec. 2.   | Dec. 2.   | Dec. 2.   | Dec. 2.   | Dec. 7. |
| Upper quarter-inch, . . . | 2,020,000 | 1,800,000 | 1,900,000 | 3,500,000 | 1,700,000 | 830,000 |
| Upper inch, . . . . .     | 2,032,800 | 1,071,400 | 1,375,000 | 2,072,800 | 1,172,800 | 528,500 |
| Upper six inches, . . .   | 1,193,200 | -         | 393,200   | 439,000   | 415,000   | 190,800 |
| Upper foot, . . . . .     | 621,900   | 158,300   | 201,600   | 265,500   | 386,700   | 131,700 |
| Second foot, . . . . .    | 131,500   | 56,200    | -         | 55,800    | 23,000    | 31,500  |
| Third foot, . . . . .     | 131,500   | 45,400    | -         | 49,800    | 18,000    | 24,500  |
| Fourth foot, . . . . .    | 110,800   | 22,200    | -         | 43,800    | 20,000    | 30,000  |
| Fifth foot, . . . . .     | 12,100    | 31,100    | -         | 46,800    | -         | -       |

*Amount of Nitrogen stored in the Sand\* at Different Depths, Dec. 8, 1893.*

[Parts per 100,000 by weight of dry sand.]

| NUMBER OF FILTER.      | 18 A. | 33 A. | 38.   | 41.  | 42.  | 43.  | 44.  | 45.  | 46.  | 47.  | 48.  | 49.  |
|------------------------|-------|-------|-------|------|------|------|------|------|------|------|------|------|
| Upper quarter-inch, .  | 17.40 | 4.70  | 10.90 | 0.50 | 8.40 | -    | 1.32 | 5.71 | 3.57 | 9.02 | 4.70 | 0.90 |
| Upper inch, . . . . .  | 11.65 | 4.91  | 8.60  | 1.05 | 7.15 | 0.55 | 5.45 | 3.61 | 2.65 | 7.56 | 4.23 | 1.58 |
| Upper six inches, . .  | 5.21  | 2.03  | 5.98  | 0.39 | 4.45 | 3.19 | 5.91 | 1.60 | 1.32 | 5.42 | 2.41 | 5.09 |
| Upper foot, . . . . .  | 6.30  | 0.72  | 4.14  | 0.05 | 3.78 | 3.47 | 4.32 | 2.47 | 2.63 | 3.77 | 0.68 | 4.42 |
| Second foot, . . . . . | 5.10  | 4.40  | 1.80  | 4.30 | -    | 1.00 | 1.37 | 2.05 | -    | 0.94 | 0.60 | 0.90 |
| Third foot, . . . . .  | 1.40  | 0.60  | -     | 0.65 | -    | 0.40 | 0.53 | 1.10 | -    | 0.54 | 0.30 | 0.47 |
| Fourth foot, . . . . . | 0.80  | 0.25  | -     | 0.90 | -    | 0.30 | 0.58 | 0.36 | -    | 0.40 | 0.35 | 0.45 |
| Fifth foot, . . . . .  | 0.91  | -     | -     | -    | -    | 0.46 | 0.57 | 0.33 | -    | 0.33 | -    | -    |

\* Nitrogen in original sand deducted.

Considerable attention was given to the species of bacteria found in the sand at different depths in Filters Nos. 33 A, 41, 44 and 47. No very marked characteristics with respect to the distribution of the species of bacteria could be found in the samples of sand from the different sources. The presence of about fifteen species was noted.

In the following table are given the results of chemical and bacteriological analyses of representative samples of the clogged sand removed from the surfaces of the filters by scraping.

The number of bacteria per gram in these samples was found to be somewhat less than in samples just below the surface, as will be seen from the tables above. The reason of this appears to arise from the difficulty with which the bacteria are detached from the grains which are so thickly coated with the accumulation of gelatinous organic matter. From this it will be understood that the merit of determinations of bacteria in sand lies in their value for comparison and not as absolute determinations.

| NUMBER OF FILTER.              | Average<br>Number<br>of Bacteria in<br>Sand per<br>Gram. | Number<br>of Analyses<br>made. | Average Quantity<br>of Nitrogen in<br>Sand.<br>—<br>(Parts per 100,000<br>by Weight<br>of Dry Sand.) | Number<br>of Analyses<br>made. |
|--------------------------------|----------------------------------------------------------|--------------------------------|------------------------------------------------------------------------------------------------------|--------------------------------|
| 33 A, . . . . .                | 820,000                                                  | 4                              | 23.9                                                                                                 | 4                              |
| 34 A, . . . . .                | 830,000                                                  | 10                             | 32.6                                                                                                 | 9                              |
| 35 A, . . . . .                | 650,000                                                  | 4                              | 26.6                                                                                                 | 3                              |
| 36 A, . . . . .                | 900,000                                                  | 7                              | 32.2                                                                                                 | 6                              |
| 38, . . . . .                  | 1,500,000                                                | 6                              | 30.5                                                                                                 | 6                              |
| 39, . . . . .                  | 580,000                                                  | 8                              | 25.3                                                                                                 | 7                              |
| 41, . . . . .                  | 540,000                                                  | 5                              | 23.3                                                                                                 | 5                              |
| 42, . . . . .                  | 900,000                                                  | 6                              | 23.8                                                                                                 | 8                              |
| 43, . . . . .                  | 910,000                                                  | 7                              | 42.3                                                                                                 | 8                              |
| 44, . . . . .                  | 640,000                                                  | 5                              | 22.1                                                                                                 | 6                              |
| 45, . . . . .                  | 540,000                                                  | 2                              | 17.4                                                                                                 | 2                              |
| Totals and averages, . . . . . | 800,000                                                  | 64                             | 27.3                                                                                                 | 64                             |

THE RELATION BETWEEN CONSTRUCTION AND OPERATION OF FILTERS  
AND THE QUANTITY OF SAND SCRAPED FROM THE SURFACES  
TO RELIEVE CLOGGING.

The data obtained in 1893 upon this point are summarized in the table below. These results cover the period May to November, inclusive. As far as can be judged from the analyses of the applied water, it is believed that they are representative for the entire year. The increased viscosity of the water during the winter months, other conditions being equal, would probably reduce somewhat the quantities of water filtered between scrapings.

The depths of sand removed were calculated in each case from the weight of the sand. It will be seen that in the case of those experimental filters having a maximum loss of head of 70 inches the volume of sand removed, per million gallons of water filtered, was in many cases approximately the same.

*Summary of Results of Scraping of Water Filters, May to November, 1893.*

| NUMBER OF<br>FILTER. | Effective<br>Size<br>of Sand<br>Grain.<br>—<br>Milli-<br>meters. | Approximate<br>Depth of<br>Sand.<br>—<br>Inches. | Maximum<br>Loss of<br>Head.<br>—<br>Inches. | Method<br>of Operation. | Number<br>of<br>Scrapings. | Average<br>Depth<br>Removed<br>at each<br>Scraping.<br>—<br>Inches. | Average<br>Quantity<br>of Water<br>Filtered<br>per Acre<br>between<br>Scrapings.<br>—<br>Gallons. | Volume of<br>Sand<br>Removed<br>per Million<br>Gallons.<br>—<br>Cubic<br>Yards. |
|----------------------|------------------------------------------------------------------|--------------------------------------------------|---------------------------------------------|-------------------------|----------------------------|---------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| 33 A, . .            | .14                                                              | 60                                               | 70                                          | Continuous.             | 8                          | .23                                                                 | 49,000,000                                                                                        | .63                                                                             |
| 34 A, . .            | .09                                                              | 45                                               | 70                                          | Continuous.             | 17                         | .12                                                                 | 14,000,000                                                                                        | 1.16                                                                            |
| 35 A,* . .           | .20                                                              | 48                                               | 70                                          | Intermittent.           | 8                          | .25                                                                 | 92,000,000                                                                                        | .36                                                                             |
| 36 A,* . .           | .20                                                              | 48                                               | 70                                          | Continuous.             | 7                          | .21                                                                 | 35,000,000                                                                                        | .82                                                                             |
| 37,* . .             | .20                                                              | 55                                               | 70                                          | Continuous.             | 1                          | .20                                                                 | 141,000,000                                                                                       | .19                                                                             |
| 38, . .              | .20                                                              | 20                                               | 35                                          | Continuous.             | 18                         | .17                                                                 | 22,000,000                                                                                        | 1.06                                                                            |
| 39,* . .             | .20                                                              | 1                                                | 23                                          | Continuous.             | 14                         | .15                                                                 | 18,000,000                                                                                        | 1.56                                                                            |
| 41, . .              | .14                                                              | 60                                               | 70                                          | Intermittent.           | 8                          | .19                                                                 | 56,000,000                                                                                        | .46                                                                             |
| 42, . .              | .20                                                              | 10                                               | 23                                          | Continuous.             | 24                         | .16                                                                 | 19,000,000                                                                                        | 1.11                                                                            |
| 43, . .              | .26                                                              | 60                                               | 70                                          | Continuous.             | 16                         | .26                                                                 | 57,000,000                                                                                        | .63                                                                             |
| 44, . .              | .29                                                              | 60                                               | 70                                          | Continuous.             | 13                         | .30                                                                 | 70,000,000                                                                                        | .58                                                                             |
| 45, . .              | .23                                                              | 60                                               | 70                                          | Intermittent.           | 4                          | .28                                                                 | 78,000,000                                                                                        | .48                                                                             |
| 46, . .              | .29                                                              | 12                                               | 23                                          | Continuous.             | 9                          | .25                                                                 | 29,000,000                                                                                        | 1.16                                                                            |
| 47, . .              | .29                                                              | 60                                               | 70                                          | Intermittent.           | 2                          | .45                                                                 | 100,000,000                                                                                       | .60                                                                             |
| 48, . .              | .38                                                              | 60                                               | 70                                          | Intermittent.           | 1                          | .88                                                                 | 181,000,000                                                                                       | .66                                                                             |
| 49, . .              | .38                                                              | 60                                               | 70                                          | Continuous.             | 4                          | .32                                                                 | 79,000,000                                                                                        | .68                                                                             |

\* Nos. 35 A and 36 A were complicated by loam layers. No. 37 was scraped but once, and during a portion of the period channels were formed at the sides. For a short time Nos. 36 A and 39 were run intermittently, while No. 35 A was operated continuously for a brief period.



### *Conclusions.*

1. The frequency of scraping increases with the fineness of the material and as the available head decreases.

2. The intermittent filters under the existing methods of operation required scraping less frequently than the continuous filters of the same construction, owing chiefly to a disturbance of the surface sand by the air which is driven from the pores of the filter.

3. These results confirm the conclusions drawn from the studies in 1892, except with regard to the effect of the method of application of water. This discrepancy is doubtless explained by the fact that Filters Nos. 35 A and 41 in 1892 contained, a foot or less from the surface, loam layers, which, together with the method of operation then practised, prevented much air from escaping at the surface.

4. As the filters grow old the sand becomes more compact. This compactness and the accumulation of matter from the water give the effect of a finer material, requiring more frequent scraping. (Filters Nos. 33A and 41 were disturbed to a depth of one foot in July, 1893, while No. 34 A was not treated in this manner.)

### THE WATER TAKEN FROM THE MERRIMACK RIVER AND APPLIED TO THE EXPERIMENTAL FILTERS.

Water taken from the Merrimack River has been applied to all of the water filters, and is brought through a two-inch galvanized iron pipe, about four hundred feet long, from the north canal of the Essex Company. The water is substantially the same as the river water above Lawrence, which is applied to the city filter. The turbidity, sediment and odor are usually very slight, but after heavy rains and during the spring freshets the turbidity and sediment become very marked. The results of analyses are given in the two tables below. In the first table are given the analyses of the water as it was drawn from the pipe. From May 12 until the discontinuance of the experiments, December 8, cultures of *B. prodigiosus*, together with the food on which these germs grew, were applied to the water which supplied the several filters, for ten hours each day. The results of analyses of the water after its inoculation with these germs are given in the second table.

*Monthly Averages of Analyses of Canal Water (Merrimack River).\**

[Parts per 100,000.]

| DATE — 1893.     | Temperature,<br>Degrees F. | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen<br>Consumed. | Per Cent. of Dis-<br>solved Oxygen. | Bacteria per Cu-<br>bic Centimeter. |
|------------------|----------------------------|--------|----------|-------------|-----------|-------------|-----------|---------------------|-------------------------------------|-------------------------------------|
|                  |                            |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                     |                                     |                                     |
| January, . . .   | 34                         | .41    | .0085    | .0207       | .23       | .019        | .0001     | .46                 | 93.                                 | 11,200                              |
| February, . . .  | 35                         | .35    | .0164    | .0225       | .34       | .022        | .0002     | .41                 | 96.                                 | 7,200                               |
| March, . . .     | 35                         | .38    | .0061    | .0204       | .18       | .020        | .0001     | .44                 | 91.                                 | 4,800                               |
| April, . . .     | 39                         | .44    | .0022    | .0146       | .13       | .011        | .0000     | .46                 | 100.                                | 2,700                               |
| May, . . .       | 53                         | .45    | .0038    | .0165       | .11       | .015        | .0000     | .45                 | 86.                                 | 2,400                               |
| June, . . .      | 67                         | .37    | .0070    | .0190       | .17       | .018        | .0000     | .39                 | 75.                                 | 5,900                               |
| July, . . .      | 72                         | .36    | .0095    | .0214       | .19       | .020        | .0002     | .33                 | 52.                                 | 4,600                               |
| August, . . .    | 72                         | .29    | .0097    | .0210       | .20       | .018        | .0001     | .27                 | 69.                                 | 4,100                               |
| September, . . . | 65                         | .39    | .0080    | .0170       | .22       | .016        | .0001     | .41                 | 81.                                 | 18,600                              |
| October, . . .   | 57                         | .34    | .0110    | .0201       | .24       | .012        | .0003     | .37                 | 86.                                 | 17,700                              |
| November, . . .  | 42                         | .47    | .0071    | .0194       | .19       | .012        | .0001     | .53                 | 95.                                 | 7,800                               |
| December, . . .  | 34                         | .44    | .0057    | .0177       | .20       | .015        | .0000     | .49                 | 98.                                 | 11,900                              |

\* For additional analyses, in which are given the residue on evaporation and observations upon the odor, turbidity and microscopical organisms, see page 181.

*Monthly Averages of Weekly Analyses of Water as applied to Filters.*

| DATE — 1893.     | Temperature,<br>Degrees F. | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed | BACTERIA PER<br>CUBIC<br>CENTIMETER. |                           |
|------------------|----------------------------|--------|----------|-------------|-----------|-------------|-----------|-----------------|--------------------------------------|---------------------------|
|                  |                            |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                 | Water Bac-<br>teria.                 | Bacillus Pro-<br>digiosa. |
| May, . . .       | 53                         | .45    | .0044    | .0197       | .11       | .015        | .0000     | .47             | 2,400                                | 3,300                     |
| June, . . .      | 67                         | .37    | .0076    | .0222       | .17       | .018        | .0000     | .40             | 5,900                                | 5,600                     |
| July, . . .      | 72                         | .36    | .0100    | .0259       | .19       | .020        | .0002     | .34             | 4,600                                | 6,900                     |
| August, . . .    | 72                         | .29    | .0103    | .0263       | .20       | .018        | .0001     | .28             | 4,100                                | 5,900                     |
| September, . . . | 65                         | .39    | .0086    | .0205       | .22       | .016        | .0001     | .42             | 18,600                               | 6,800                     |
| October, . . .   | 57                         | .34    | .0116    | .0241       | .24       | .012        | .0003     | .38             | 17,700                               | 6,800                     |
| November, . . .  | 42                         | .47    | .0077    | .0233       | .19       | .012        | .0001     | .54             | 7,800                                | 6,100                     |
| December, . . .  | 34                         | .44    | .0063    | .0212       | .20       | .015        | .0000     | .50             | 11,900                               | 6,100                     |

### DETAILED ACCOUNT OF THE WORK OF THE SEVERAL WATER FILTERS IN 1893.

The remaining pages contain a summary of the weekly averages of all bacterial results, followed by a brief description of the operation of each filter and monthly averages of both chemical and bacterial analyses. One bacterial sample was examined daily from each effluent from January until May. These results are more or less abnormal because the conditions existing in the filters were abnormal from time to time. This was caused partly by the formation of channels at the sides of the iron tanks due to freezing weather, and partly to the evolution of air by the water as it increased in temperature, which produced channels within the filters. These conditions were touched upon in the 1892 Report. It is believed that they would not appear in large filters in actual practice. On account of these peculiar and unfavorable circumstances the results obtained from January to May do not appear in the foregoing discussion, and for the same reason the experiments were discontinued during the winter of 1893-94.

#### *General Plan of the Experiments.*

Beginning May 12 *B. prodigiosus* was regularly applied to each filter for ten hours a day on six days in a week. The general plan of the experiments was the same as during the preceding year (see the 1892 Report, page 529). A pure culture of this species of bacteria was obtained by inoculation and growth for four days at 20° C. in a solution of one-tenth per cent. peptone and two-tenths per cent. glucose in city water. This solution was applied to the filters in the proportion of one part to three thousand parts of water, at intervals of one or two hours during the day, according to the rate of filtration. Throughout the experiments four examinations were made daily of each of the effluents, at a time when the water from the applied doses was passing through the outlet-pipes. The reasons that this species of bacteria was used are that it is easy to differentiate from ordinary water bacteria and is apparently very similar to the germ of typhoid fever [of Eberth] in its mode of life in the river water.

The experiments have been conducted with as much uniformity as possible, and the system practised has been substantially the same as that of the preceding year. Notes of the slight changes that have

been made will be found in the proper places. When considering the depths to which the filters were reduced, largely by scraping, it is to be borne in mind that this diminution is partly accounted for by settling. In November most of the filters were filled with water from below (in some cases very rapidly) after scraping, and this, together with the very high rates of filtration, increased the average number of bacteria in the effluents.

In the first table below will be found the results of the mechanical analyses of the sands in the various water filters. The underdrains were 5 inches deep in each case. Filters Nos. 3 B and 8 A are each one two-hundredth of an acre in area and are out of doors. The other water filters are 20 inches in diameter, equivalent to one twenty-thousandth of an acre, and are all placed within the buildings.

The second table beyond contains the weekly averages of the numbers of bacteria in the applied water and in the various effluents. Following this are brief descriptions and monthly averages of the chemical and bacterial analyses of the effluents of the several filters.

The report ends with a detailed account of the results of analyses obtained from the Lawrence city filter and also from the duplicate filters at the Experiment Station, Nos. 3 B and 8 A.

*Mechanical Composition of Materials used for Water Filters in 1893.*

| DIAMETER IN MILLIMETERS.                                           | PER CENT. BY WEIGHT OF GRAINS IN FILTERS NOS.— |       |      |      |      |       |       |       |
|--------------------------------------------------------------------|------------------------------------------------|-------|------|------|------|-------|-------|-------|
|                                                                    | 18 A.                                          | 48.   | 44.  | 43.  | 45.  | 42.   | 41.   | 34 A. |
| Finer than 5.9, . . . . .                                          | 100.0                                          | 100.0 | —    | —    | —    | —     | —     | —     |
| " " 3.9, . . . . .                                                 | 97.0                                           | 96.0  | —    | 98.0 | 98.0 | —     | 100.0 | —     |
| " " 2.04, . . . . .                                                | 93.0                                           | 72.0  | 98.0 | 85.0 | 95.0 | 100.0 | 99.0  | —     |
| " " .93, . . . . .                                                 | 32.0                                           | 45.0  | 78.0 | 54.0 | 91.0 | 97.0  | 95.0  | 100.0 |
| " " .46, . . . . .                                                 | 8.0                                            | 17.0  | 32.0 | 26.0 | 50.0 | 87.0  | 70.0  | 99.0  |
| " " .316, . . . . .                                                | 4.0                                            | 5.0   | 12.0 | 14.0 | 22.0 | 44.0  | 38.0  | 94.0  |
| " " .184, . . . . .                                                | 1.3                                            | 0.9   | 3.7  | 5.4  | 5.5  | 9.0   | 15.0  | 52.0  |
| " " .105, . . . . .                                                | 0.0                                            | 0.2   | 0.8  | 1.4  | 0.9  | 0.4   | 5.4   | 11.2  |
| " " .08, . . . . .                                                 | —                                              | —     | —    | —    | —    | —     | —     | 3.0   |
| " " .04, . . . . .                                                 | —                                              | —     | —    | —    | —    | —     | —     | 0.5   |
| Effective size (millimeter), . . . . .                             | .48                                            | .38   | .29  | .26  | .23  | .20   | .14   | .09   |
| Uniformity co-efficient, . . . . .                                 | 2.4                                            | 3.5   | 2.7  | 3.7  | 2.3  | 1.6   | 2.2   | 2.1   |
| Estimated maximum rate (million gallons per acre daily), . . . . . | 184.0                                          | 116.0 | 67.0 | 53.0 | 42.0 | 32.0  | 16.0  | 7.0   |
| Organic nitrogen (parts per 100,000),* . . . .                     | 1.0                                            | .8    | .8   | .8   | .8   | 1.3   | .8    | .8    |

\* Calculated as  $\frac{1}{4}$  of the albuminoid ammonia doubled.

The "effective size" of the sand grains means that ten per cent. by weight of the grains are finer than the diameter given. The "uniformity coefficient" is the ratio A to B when the values of A and B are such that sixty per cent. by weight of the material is finer than A and ten per cent. finer than B. The "maximum rate" is the maximum quantity of water, expressed in million gallons per acre daily, which, at a temperature of 50° F., will pass through a filter of clean sand with no air in its pores, and with no suspended matter upon its surface when the acting head is equal to the depth of sand.

The sand in No. 48 is the same as in No. 49; No. 44 as in Nos. 46 and 47; No. 45 as in Nos. 3 B and 8 A; No. 42 as in Nos. 35 A, 36 A, 37, 38 and 39; and No. 41 the same as in No. 33 A.

The sand in No. 44 corresponds quite closely with the "No. 70" sand in the Lawrence city filter, and No. 45 with "No. 50" sand in the city filter.

Table showing the Number of Bacteria per Cubic Centimeter in the Applied Water and the Effluents from the Various Filters arranged as Weekly Averages of Daily Analyses.

| BACTERIA<br>IN APPLIED<br>WATER. |                    |                          | BACTERIA IN EFFLUENTS FROM FILTERS NOS. — |                          |                    |                          |                    |                          |                    |                          |                    |                          |                    |                          |                    |                          |                    |                          |                    |                          |
|----------------------------------|--------------------|--------------------------|-------------------------------------------|--------------------------|--------------------|--------------------------|--------------------|--------------------------|--------------------|--------------------------|--------------------|--------------------------|--------------------|--------------------------|--------------------|--------------------------|--------------------|--------------------------|--------------------|--------------------------|
| DATE.<br>WEEK ENDING —           | 18 A.              |                          | 33 A.                                     |                          | 34 A.              |                          | 35 A.              |                          | 36 A.              |                          | 37.                |                          | 38.                |                          | 39.                |                          | 41.                |                          | 42.                |                          |
|                                  | Water<br>Bacteria. | Bacillus<br>Prodigiouus. | Water<br>Bacteria.                        | Bacillus<br>Prodigiouus. | Water<br>Bacteria. | Bacillus<br>Prodigiouus. | Water<br>Bacteria. | Bacillus<br>Prodigiouus. | Water<br>Bacteria. | Bacillus<br>Prodigiouus. | Water<br>Bacteria. | Bacillus<br>Prodigiouus. | Water<br>Bacteria. | Bacillus<br>Prodigiouus. | Water<br>Bacteria. | Bacillus<br>Prodigiouus. | Water<br>Bacteria. | Bacillus<br>Prodigiouus. | Water<br>Bacteria. | Bacillus<br>Prodigiouus. |
| 1893.                            |                    |                          |                                           |                          |                    |                          |                    |                          |                    |                          |                    |                          |                    |                          |                    |                          |                    |                          |                    |                          |
| Jan. 7, . . .                    | 19,200             | 0                        | 1,028                                     | 81                       | 188                | 531                      | 579                | 1,218                    | 1,028              | 835                      | 717                | 716                      | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
| 14, . . .                        | 16,000             | 0                        | 502                                       | 54                       | 230                | 250                      | 380                | 546                      | 456                | 639                      | 339                | 238                      | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
| 21, . . .                        | 4,800              | 0                        | 136                                       | 103                      | 164                | 401                      | 635                | 63                       | 160                | 289                      | 234                | 145                      | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
| 28, . . .                        | 3,700              | 0                        | 97                                        | 82                       | 102                | 194                      | 182                | 37                       | 60                 | 80                       | 148                | 42                       | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
| Feb. 4, . . .                    | 6,200              | 0                        | 358                                       | 167                      | 137                | 66                       | 66                 | 36                       | 36                 | 56                       | 145                | 17                       | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
| 11, . . .                        | 7,500              | 0                        | 248                                       | 118                      | 183                | 718                      | 476                | 302                      | 367                | 492                      | 342                | 180                      | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
| 19, . . .                        | 15,000             | 0                        | 76                                        | 59                       | 212                | 117                      | 104                | 32                       | 116                | 137                      | 242                | 38                       | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
| 26, . . .                        | 478                | 0                        | 69                                        | 59                       | 68                 | 108                      | 48                 | 31                       | 102                | 89                       | 36                 | 37                       | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
| March 5, . . .                   | 3,500              | 0                        | 104                                       | 27                       | 45                 | 30                       | 43                 | 43                       | 31                 | 26                       | 30                 | 18                       | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
| 12, . . .                        | 4,000              | 0                        | 72                                        | 31                       | 39                 | 33                       | 57                 | 43                       | 65                 | 56                       | 83                 | 26                       | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
| 19, . . .                        | 7,700              | 0                        | 262                                       | 77                       | 42                 | 55                       | 62                 | 109                      | 84                 | 179                      | 186                | 39                       | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
| 26, . . .                        | 4,200              | 0                        | 57                                        | 39                       | 26                 | 65                       | 16                 | 22                       | 22                 | 73                       | 45                 | 16                       | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
| April 2, . . .                   | 3,900              | 0                        | 45                                        | 8                        | 26                 | 149                      | 17                 | 17                       | 23                 | 45                       | 37                 | 26                       | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
| 9, . . .                         | 3,400              | 0                        | 29                                        | 10                       | 25                 | 37                       | 19                 | 21                       | 19                 | 29                       | 39                 | 28                       | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
| 16, . . .                        | 2,300              | 0                        | 22                                        | 12                       | 21                 | 14                       | 23                 | 11                       | 11                 | 19                       | 28                 | 19                       | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
| 23, . . .                        | 2,400              | 0                        | 14                                        | 13                       | 7                  | 35                       | 9                  | 15                       | 14                 | 13                       | 20                 | 17                       | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
| 30, . . .                        | 2,800              | 0                        | 13                                        | 73                       | 33                 | 33                       | 1                  | 16                       | 15                 | 19                       | 18                 | 6                        | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
| May 7, . . .                     | 4,200              | 0                        | 22                                        | 21                       | 44                 | 44                       | 11                 | 14                       | 17                 | 103                      | 18                 | 29                       | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
| 13, . . .                        | 2,000              | 3,600                    | 34                                        | 10                       | 12                 | 13                       | 8                  | 27                       | 12                 | 74                       | 44                 | 44                       | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
| 20, . . .                        | 1,900              | 2,700                    | 18                                        | 10                       | 11                 | 7                        | 9                  | 8                        | 14                 | 36                       | 10                 | 17                       | —                  | —                        | —                  | —                        | —                  | —                        | —                  | —                        |
|                                  |                    |                          |                                           |                          | 0.3                | 1.5                      | 2.0                | 0                        | 0.9                | 10.3                     | 0.6                | 1.9                      |                    |                          |                    |                          |                    |                          |                    |                          |

Table of Weekly Averages of Bacteria in the Effluents from the various Filters — Continued.

| DATE.<br>WEEK<br>ENDING —<br>1893. | BACTERIA<br>IN APPLIED<br>WATER. |                            | BACTERIA IN EFFLUENTS FROM FILTERS NOS. — |                            |                    |                            |                    |                            |                    |                            |                    |                            |                    |                            |                    |                            |                    |                            |                    |                            |                    |                            |                    |                            |                    |                            |
|------------------------------------|----------------------------------|----------------------------|-------------------------------------------|----------------------------|--------------------|----------------------------|--------------------|----------------------------|--------------------|----------------------------|--------------------|----------------------------|--------------------|----------------------------|--------------------|----------------------------|--------------------|----------------------------|--------------------|----------------------------|--------------------|----------------------------|--------------------|----------------------------|--------------------|----------------------------|
|                                    | Water<br>Bacteria.               | Prodigiousus.<br>Bacillus. | 18 A.                                     |                            | 33 A.              |                            | 34 A.              |                            | 35 A.              |                            | 36 A.              |                            | 37.*               |                            | 38.                |                            | 39.                |                            | 41.                |                            | 42.                |                            | 43.                |                            | 44.                |                            |
|                                    |                                  |                            | Water<br>Bacteria.                        | Prodigiousus.<br>Bacillus. | Water<br>Bacteria. | Prodigiousus.<br>Bacillus. | Water<br>Bacteria. | Prodigiousus.<br>Bacillus. | Water<br>Bacteria. | Prodigiousus.<br>Bacillus. | Water<br>Bacteria. | Prodigiousus.<br>Bacillus. | Water<br>Bacteria. | Prodigiousus.<br>Bacillus. | Water<br>Bacteria. | Prodigiousus.<br>Bacillus. | Water<br>Bacteria. | Prodigiousus.<br>Bacillus. | Water<br>Bacteria. | Prodigiousus.<br>Bacillus. | Water<br>Bacteria. | Prodigiousus.<br>Bacillus. | Water<br>Bacteria. | Prodigiousus.<br>Bacillus. | Water<br>Bacteria. | Prodigiousus.<br>Bacillus. |
| May 27,                            | 2,000                            | 3,700                      | 20                                        | -                          | 7                  | 5.3                        | 8                  | 0.9                        | 5                  | -                          | 13                 | -                          | 5                  | 0.2                        | 9                  | 2.6                        | 20                 | 8.8                        | 7                  | 2.7                        | 9                  | 0.7                        | 1,339              | 67.0                       | 391                | 74.0                       |
| June 3,                            | 2,700                            | 5,200                      | 30                                        | -                          | 10                 | 1.3                        | 8                  | 2.3                        | 31                 | -                          | 18                 | -                          | 8                  | 0.2                        | 12                 | 1.0                        | 23                 | 4.5                        | 10                 | 1.2                        | 12                 | 1.8                        | 541                | 20.0                       | 172                | 24.0                       |
| 10,                                | 7,000                            | 6,500                      | 18                                        | -                          | 10                 | 0.8                        | 11                 | 1.6                        | 9                  | -                          | 15                 | -                          | 17                 | 0.4                        | 12                 | 1.0                        | 75                 | 4.5                        | 11                 | 2.1                        | 22                 | 1.6                        | 287                | 3.8                        | 118                | 8.0                        |
| 17,                                | 7,000                            | 5,400                      | 12                                        | -                          | 12                 | 0.6                        | 8                  | 1.0                        | 5                  | 0.4                        | 11                 | 0.3                        | 9                  | 3.1                        | 8                  | 1.2                        | 13                 | 7.1                        | 6                  | 0.2                        | 9                  | 1.0                        | 202                | -                          | 51                 | -                          |
| 24,                                | 4,300                            | 11,100                     | 11                                        | -                          | 6                  | 0.1                        | 6                  | 0.1                        | 9                  | 2.6                        | 4                  | 0.0                        | 14                 | 3.0                        | 9                  | 0.7                        | 31                 | 12.9                       | 11                 | 2.5                        | 15                 | 3.4                        | 225                | -                          | 50                 | -                          |
| July 1,                            | 7,400                            | 5,000                      | 17                                        | -                          | 29                 | 0.8                        | 21                 | 0.0                        | 14                 | 3.0                        | 22                 | 0.4                        | Filter No.<br>45.† |                            | 39                 | 1.7                        | 23                 | 13.5                       | 12                 | 1.3                        | 15                 | 2.5                        | 202                | -                          | 46                 | -                          |
| 8,                                 | 5,500                            | 6,900                      | 28                                        | -                          | 15                 | 4.2                        | 34                 | 0.8                        | 17                 | 1.0                        | 64                 | 11.0                       | 1,586              |                            | 31                 | 3.5                        | 62                 | 20.3                       | 17                 | 1.8                        | 17                 | 9.0                        | 140                | 5.2                        | 23                 | 3.8                        |
| 15,                                | 5,200                            | 6,000                      | 63                                        | -                          | 48                 | 1.4                        | 15                 | 1.2                        | 31                 | 0.4                        | 52                 | 1.6                        | 92.0               | 55                         | 3.9                | 455                        | 43.0               | 39                         | 1.7                | 23                         | 1.6                | 63                         | 4.0                | 44                         | 6.0                |                            |
| 22,                                | 5,000                            | 6,700                      | 316                                       | 67.0                       | 23                 | 2.6                        | 33                 | 2.0                        | 75                 | 10.0                       | 78                 | 4.0                        | 279                | 140.2                      | 80                 | 8.0                        | 338                | 109.0                      | 40                 | 7.0                        | 132                | 5.4                        | 38                 | 8.4                        | 30                 | 13.0                       |
| 29,                                | 3,500                            | 9,100                      | 128                                       | 50.0                       | 306                | 2.2                        | 15                 | 1.2                        | 88                 | 9.0                        | 234                | 8.2                        | 177                | 52.2                       | 341                | 4.8                        | 595                | 178.0                      | 47                 | 7.0                        | 318                | 6.0                        | 58                 | 5.2                        | 19                 | 7.5                        |
| Aug. 5,                            | 4,100                            | 7,500                      | 119                                       | 41.0                       | 54                 | 4.7                        | 19                 | 3.3                        | 54                 | 11.0                       | 70                 | 1.8                        | 155                | 32.0                       | 28                 | 6.5                        | 804                | 181.5                      | 49                 | 12.3                       | 83                 | 4.2                        | 33                 | 11.2                       | 25                 | 11.5                       |
| 12,                                | 4,800                            | 5,300                      | 90                                        | 28.5                       | 90                 | 1.7                        | 14                 | 1.7                        | 22                 | 4.7                        | 161                | 1.1                        | 81                 | 19.0                       | 133                | 3.8                        | 284                | 62.5                       | 30                 | 4.3                        | 35                 | 3.3                        | 29                 | 5.0                        | 19                 | 2.4                        |
| 19,                                | 3,500                            | 5,500                      | 85                                        | 39.2                       | 51                 | 1.7                        | 31                 | 1.6                        | 19                 | 1.4                        | 84                 | 6.5                        | 62                 | 30.0                       | 58                 | 3.7                        | 43                 | 99.2                       | 32                 | 7.2                        | 20                 | 3.7                        | 23                 | 6.0                        | 40                 | 11.0                       |

\* Filter No. 37 was discontinued on June 26, 1893.

† Filter No. 45 was started July 10, 1893.





## FILTER No. 18 A.

This filter, 20 inches in diameter, contains sand of an effective size of 0.48 millimeter and has been in operation since Sept. 17, 1889. The original depth of the sand was 62 inches. Up to January, 1891, city water was applied in hourly doses, fourteen hours a day on six days a week, at the rate of about one million gallons per acre daily. The faucet at the outlet was always kept wide open until Oct. 1, 1893, and the rate of filtration regulated at the top. The outlet has never been trapped. With the exception of a few scattering days river water taken from the canal has been applied since Aug. 18, 1891. From January, 1891, to July, 1893, the water was applied by an automatic arrangement in small doses equivalent to 5,000 gallons per acre once in three to seven minutes, days, nights and Sundays, according to the rate of filtration. On July 17, 1893, the siphon attachment, by which the water was applied intermittently, was removed and the water applied constantly for sixteen hours a day on six days in a week. Beginning October 1 the faucet at the outlet was closed at 5 A.M. daily after draining over night and the water applied at the top; after the surface was covered the faucet was opened below to give the desired rate of filtration, and the surface was kept covered until the water was shut off at 9 P.M. With the exception of November 21 to 30 this method was followed through the rest of the year.

No sand was scraped from the surface until November, 1892, when it was necessary to remove  $2\frac{1}{2}$  inches in order to keep the action of the filter intermittent. During the four years of its operation the surface was scraped five times and 8 inches of sand were removed without replacement; the water filtered in this time was equivalent to 1,500,000,000 gallons per acre. The sand removed was equivalent to 0.70 cubic yard per million gallons of water filtered. It will be seen that this quantity agrees approximately with some of the results from other filters presented on page 487. On October 9 clean sand was added and the filter restored to its original depth.

*Monthly Averages of Analyses of Effluent of Filter No. 18 A.*

[Parts per 100,000.]

| DATE—1893.   | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen.* | BACTERIA PER CUBIC CENTIMETER. |                       |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|---------------------------------|--------------------------------|-----------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                 | Water Bacteria.                | Bacillus Prodigiosus. |
| January, .   | 1,660,000                                        | 34                      | 36        | .29    | .0080    | .0104       | .29       | .0300       | .0002     | .32              | 98                              | 614                            | —                     |
| February, .  | 1,680,000                                        | 35                      | 36        | .27    | .0083    | .0115       | .25       | .0280       | .0005     | .31              | 98                              | 244                            | —                     |
| March, .     | 1,840,000                                        | 35                      | 35.5      | .27    | .0040    | .0084       | .17       | .0200       | .0002     | .37              | 98                              | 90                             | —                     |
| April, .     | 1,380,000                                        | 39                      | 42.7      | .33    | .0021    | .0095       | .12       | .0210       | .0000     | .31              | 100                             | 20                             | —                     |
| May, .       | 1,530,000                                        | 53                      | 53.3      | .41    | .0021    | .0108       | .10       | .0270       | .0000     | .40              | 97                              | 24                             | —                     |
| June, .      | 2,300,000                                        | 67                      | 68        | .29    | .0018    | .0093       | .16       | .0290       | .0000     | .29              | 91                              | 18                             | —                     |
| July, .      | 1,680,000                                        | 72                      | 68        | .25    | .0017    | .0109       | .20       | .0410       | .0000     | .24              | 93                              | 222                            | 58                    |
| August, .    | 1,920,000                                        | 72                      | 71.6      | .17    | .0022    | .0096       | .20       | .0310       | .0000     | .18              | 92                              | 148                            | 29                    |
| September, . | 1,740,000                                        | 65                      | 65        | .24    | .0017    | .0117       | .22       | .0260       | .0002     | .28              | 89                              | 2,375                          | 19                    |
| October, .   | 1,640,000                                        | 57                      | 55        | .36    | .0025    | .0137       | .23       | .0230       | .0000     | .43              | 96                              | 1,002                          | 52                    |
| November, .  | 1,760,000                                        | 42                      | 43.7      | .34    | .0024    | .0124       | .20       | .0230       | .0003     | .39              | 100                             | 167                            | 11                    |
| December, .  | 4,120,000                                        | 34                      | 34        | .41    | .0060    | .0144       | .20       | .0220       | .0002     | .48              | 100                             | 1,004                          | 57                    |

\* In all cases the dissolved oxygen is expressed as per cent. of the amount required to saturate the water at the temperature when collected.

## FILTER No. 33 A.

This filter was put in operation April 28, 1892, and contains sand of an effective size of 0.14 millimeter. The original depth was 60 inches. The method of operation has been continuous, except from April 17 to 30, 1893, and for a few days at irregular intervals during the winter, when the filter was accidentally drained, owing to freezing of the water pipes. The rate of filtration has been regulated by the faucet at the outlet, to which a trap is attached. From May 25 to December 8 the filter was scraped 8 times, an average of once in 23 days. The average depth removed at a scraping was 0.23 inch; the average quantity filtered between scrapings was equivalent to 49 million gallons per acre, and the sand removed was equivalent to 0.63 cubic yard per million gallons. On July 17 the upper foot of sand was removed and replaced, as was described on page 465. Until October 6 the sand removed by scraping was not replaced, but on that date the depth was restored from 47 inches to its original depth of 60 inches. After this date the sand was replaced at the time of scraping.

*Monthly Averages of Analyses of Effluent of Filter No. 33 A.*

[Parts per 100,000.]

| DATE—1893.   | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |          | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | BACTERIA PER CUBIC CENTIMETER. |                       |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|----------|------------------|--------------------------------|--------------------------------|-----------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrate.    | Nitrite. |                  |                                | Water Bacteria.                | Bacillus Prodigiosus. |
| January, .   | 1,540,000                                        | 34                      | 37        | .27    | .0040    | .0096       | .29       | .0300       | .0000    | .30              | 79                             | 81                             | -                     |
| February, .  | 1,840,000                                        | 35                      | 37        | .27    | .0034    | .0082       | .19       | .0225       | .0000    | .28              | 71                             | 118                            | -                     |
| March, .     | 1,860,000                                        | 35                      | 38        | .25    | .0019    | .0078       | .17       | .0185       | .0000    | .32              | 69                             | 30                             | -                     |
| April, .     | 1,660,000                                        | 39                      | 45        | .33    | .0007    | .0096       | .11       | .0215       | .0000    | .33              | 76                             | 27                             | -                     |
| May, .       | 1,720,000                                        | 53                      | 53        | .41    | .0011    | .0095       | .10       | .0185       | .0000    | .42              | 55                             | 8                              | 0.7                   |
| June, .      | 1,740,000                                        | 67                      | 68        | .28    | .0011    | .0087       | .15       | .0335       | .0000    | .29              | 38                             | 15                             | 0.7                   |
| July, .      | 1,860,000                                        | 72                      | 68        | .22    | .0015    | .0096       | .19       | .0347       | .0000    | .21              | 8                              | 98                             | 2.5                   |
| August, .    | 2,700,000                                        | 72                      | 69        | .17    | .0023    | .0098       | .20       | .0297       | .0013    | .16              | 12                             | 107                            | 2.2                   |
| September, . | 1,920,000                                        | 65                      | 62        | .22    | .0020    | .0094       | .21       | .0290       | .0000    | .26              | 31                             | 53                             | 2.0                   |
| October, .   | 1,940,000                                        | 57                      | 55        | .23    | .0023    | .0102       | .24       | .0262       | .0000    | .29              | 54                             | 39                             | 0.3                   |
| November, .  | 2,780,000                                        | 42                      | 44        | .35    | .0025    | .0107       | .18       | .0223       | .0000    | .39              | 81                             | 29                             | 0.9                   |
| December, .  | 4,000,000                                        | 34                      | 35        | .37    | .0068    | .0118       | .20       | .0210       | .0000    | .43              | 87                             | 422                            | 25.0                  |

## FILTER NO. 34 A.

This filter contained sand of an effective size of 0.09 millimeter, and its original depth was 60 inches. It was operated continuously after it was first put in operation, April 28, 1892. The rate of filtration was regulated at the outlet by a faucet to which a trap was attached.

From May 12 to September 7, 1893, the date of its discontinuance, the surface was scraped 17 times to relieve clogging. It was scraped on an average once in 7 days. The average depth removed was 0.12 inch; the average quantity of water filtered between scrapings was equivalent to 14 million gallons per acre, and the sand removed was equivalent to 1.16 cubic yards per million gallons. The depth of sand at the date of its discontinuance was 44 inches.

*Monthly Averages of Analyses of Effluent of Filter No. 34 A.*

[Parts per 100,000.]

| DATE — 1893. | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | BACTERIA PER CUBIC CENTIMETER. |                       |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|-----------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                | Water Bacteria.                | Bacillus Prodigiosus. |
| January, .   | 1,340,000                                        | 34                      | 37        | .27    | .0051    | .0101       | .30       | .0250       | .0000     | .31              | 73                             | 200                            | -                     |
| February, .  | 1,620,000                                        | 35                      | 37.3      | .29    | .0054    | .0098       | .20       | .0230       | .0000     | .31              | 74                             | 147                            | -                     |
| March, .     | 1,520,000                                        | 35                      | 39        | .26    | .0035    | .0066       | .18       | .0200       | .0000     | .31              | 80                             | 30                             | -                     |
| April, .     | 1,320,000                                        | 39                      | 45.3      | .33    | .0013    | .0109       | .12       | .0230       | .0000     | .30              | 75                             | 22                             | -                     |
| May, .       | 1,560,000                                        | 53                      | 55.3      | .40    | .0009    | .0093       | .11       | .0210       | .0000     | .42              | 65                             | 9                              | 1.7                   |
| June, .      | 1,420,000                                        | 67                      | 68.3      | .30    | .0036    | .0104       | .16       | .0290       | .0000     | .28              | 54                             | 12                             | 0.8                   |
| July, .      | 1,860,000                                        | 72                      | 67.5      | .20    | .0012    | .0104       | .19       | .0290       | .0010     | .22              | 22                             | 24                             | 1.2                   |
| August, .    | 2,300,000                                        | 72                      | 70.5      | .16    | .0017    | .0091       | .20       | .0260       | .0000     | .17              | 18                             | 39                             | 1.6                   |

**FILTER NO. 35 A.**

This filter was constructed on March 30, 1892, and contained sand of an effective size of 0.20 millimeter. The original depth was 57.5 inches, and 1 foot below the surface was a layer of loam 1 inch thick. April 17 to 30 and July 31 to September 6, 1893, it was operated continuously with the trap attached to the outlet in the usual manner. During the remainder of the time it was operated intermittently, with the untrapped faucet at the outlet wide open and the rate regulated at the top. The water was applied sixteen hours a day on six days in a week. On July 17, when the layer of loam was less than 3 inches below the surface, the sand was taken out down to the loam, which was removed and the sand replaced.

From May 24 to September 7, the date of its discontinuance, the surface was scraped three times to relieve clogging, and the average depth removed was 0.25 inch. The average quantity of water filtered between scrapings was equivalent to 92 million gallons per acre. It was scraped on an average once in 33 days, and the sand removed was equivalent to 0.36 cubic yard per million gallons.

The depth of the sand on September 7 was 49 inches.

*Monthly Averages of Analyses of Effluent of Filter No. 35 A.*

[Parts per 100,000.]

| DATE — 1893. | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | BACTERIA PER CUBIC CENTIMETER. |                       |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|-----------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                | Water Bacteria.                | Bacillus Prodigiosus. |
| January, .   | 960,000                                          | 34                      | 37.8      | .24    | .0065    | .0071       | .27       | .0380       | .0000     | .26              | 96                             | 398                            | —                     |
| February, .  | 860,000                                          | 35                      | 37.8      | .28    | .0060    | .0081       | .19       | .0290       | .0000     | .25              | 74                             | 399                            | —                     |
| March, .     | 920,000                                          | 35                      | 39.5      | .28    | .0024    | .0094       | .17       | .0230       | .0000     | .35              | 100                            | 55                             | —                     |
| April, .     | 1,580,000                                        | 39                      | 44.3      | .35    | .0010    | .0093       | .13       | .0170       | .0000     | .38              | 94                             | 30                             | —                     |
| May, .       | 1,400,000                                        | 53                      | 55.3      | .38    | .0020    | .0097       | .11       | .0400       | .0000     | .38              | 91                             | 17                             | —                     |
| June, .      | 1,180,000                                        | 67                      | 72.0      | .28    | .0027    | .0086       | .16       | .0580       | .0000     | .26              | 84                             | 9                              | 1.9                   |
| July, .      | 1,680,000                                        | 72                      | 71.1      | .21    | .0013    | .0097       | .19       | .0410       | .0000     | .21              | 89                             | 53                             | 5.0                   |
| August, .    | 2,960,000                                        | 72                      | 70.2      | .15    | .0021    | .0089       | .20       | .0340       | .0001     | .16              | 50                             | 22                             | 3.6                   |

**FILTER NO. 36 A.**

This filter was constructed on the same date and in the same manner as No. 35 A. It was operated continuously, except from April 17 to 30 and from July 31 to September 7, when it was operated intermittently in the same manner as No. 35 A.

From May 12 to September 7, 1893, the date of its discontinuance, the surface was scraped 7 times to relieve clogging, and the average depth removed was 0.21 inch. The average quantity of water filtered between scrapings was equivalent to 35 million gallons per acre. It was scraped on an average once in 14 days, and the sand removed was equivalent to 0.82 cubic yard per million gallons.

The depth of sand on September 6 was 48 inches.

*Monthly Averages of Analyses of Effluent of Filter No. 36 A.*

[Parts per 100,000.]

| DATE — 1893. | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | BACTERIA PER CUBIC CENTIMETER. |                       |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|-----------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                | Water Bacteria.                | Bacillus Prodigiosus. |
| January, .   | 1,480,000                                        | 34                      | 37.5      | .25    | .0060    | .0075       | .27       | .0300       | .0000     | .29              | 69                             | 539                            | —                     |
| February, .  | 1,540,000                                        | 35                      | 36.5      | .28    | .0029    | .0000       | .19       | .0290       | .0000     | .31              | 65                             | 273                            | —                     |
| March, .     | 1,860,000                                        | 35                      | 38.0      | .26    | .0018    | .0090       | .17       | .0240       | .0000     | .33              | 66                             | 33                             | —                     |
| April, .     | 1,600,000                                        | 39                      | 43.5      | .36    | .0007    | .0119       | .13       | .0310       | .0000     | .35              | 86                             | 13                             | —                     |
| May, .       | 2,020,000                                        | 53                      | 54.3      | .38    | .0018    | .0101       | .11       | .0230       | .0000     | .41              | 71                             | 12                             | —                     |
| June, .      | 2,060,000                                        | 67                      | 68.7      | .28    | .0016    | .0088       | .17       | .0390       | .0000     | .27              | 64                             | 12                             | 0.3                   |
| July, .      | 3,040,000                                        | 72                      | 68.8      | .22    | .0021    | .0097       | .20       | .0390       | .0006     | .23              | 15                             | 107                            | 6.0                   |
| August, .    | 1,660,000                                        | 72                      | 70.4      | .16    | .0024    | .0091       | .20       | .0490       | .0000     | .16              | 86                             | 157                            | 3.8                   |
| September, . | 1,200,000                                        | 65                      | 63.0      | .23    | .0008    | .0088       | .21       | .0330       | .0000     | .31              | —                              | 30                             | 1.0                   |

FILTER No. 37.

This filter was constructed on April 18, 1892, and contained originally 61 inches in depth of sand having an effective size of 0.20 millimeter. It was operated continuously until June 25, 1893, when the experiment was discontinued, owing to an accident which happened to the tank.

The results obtained from this filter are more or less affected by evolution of air from the water and the formation of channels at the sides of the iron tank, as is indicated by the results of the analyses below and by the fact that this filter of medium fine sand was operated for more than three months during the winter without scraping. It was scraped on June 19 to relieve clogging, and 0.20 inch was removed. The depth of sand on this date was 55 inches.

Monthly Averages of Analyses of Effluent of Filter No. 37.

[Parts per 100,000.]

| DATE - 1893. | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | BACTERIA PER CUBIC CENTIMETER. |                       |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|-----------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                | Water Bacteria.                | Bacillus Prodigiosus. |
| January, .   | 1,780,000                                        | 34                      | 36        | .26    | .0001    | .0082       | .29       | .0270       | .0000     | .27              | 70                             | 460                            | -                     |
| February, .  | 1,740,000                                        | 35                      | 36        | .28    | .0085    | .0101       | .25       | .0280       | .0001     | .29              | 72                             | 168                            | -                     |
| March, .     | 2,000,000                                        | 35                      | 37.8      | .25    | .0022    | .0079       | .17       | .0230       | .0000     | .32              | 75                             | 39                             | -                     |
| April, .     | 1,640,000                                        | 39                      | 43        | .34    | .0010    | .0116       | .12       | .0180       | .0000     | .35              | 60                             | 18                             | -                     |
| May, .       | 1,680,000                                        | 53                      | 55        | .38    | .0013    | .0093       | .11       | .0200       | .0000     | .40              | 56                             | 7                              | 0.0                   |
| June, .      | 3,360,000                                        | 67                      | 68        | .29    | .0022    | .0098       | .16       | .0270       | .0000     | .29              | 62                             | 13                             | 1.9                   |

FILTER No. 38.

This filter contained sand of an effective size of 0.20 millimeter, and its original depth was 24 inches. The date of its construction was April 28, 1892. It has been operated continuously in the usual manner.

From May 25 to December 4 the surface was scraped 18 times to relieve clogging. It was scraped on an average once in 11 days. The average depth removed was 0.17 inch; the average quantity of water filtered between scrapings was equivalent to 22 million gal-

lons per acre, and the sand removed was equivalent to 1.06 cubic yards per million gallons.

The sand removed by scraping was not replaced with clean material until Sept. 12, 1893. The depth of sand was about 14 inches on that date, when the filter was refilled to its original depth. From this time on the sand was replaced at the time of scraping. The addition of new sand in September caused a greater (percentage) removal of color.

*Monthly Averages of Analyses of Effluent of Filter No. 38.*

[Parts per 100,000.]

| DATE - 1893. | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | BACTERIA PER CUBIC CENTIMETER. |                       |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|-----------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                | Water Bacteria.                | Bacillus Prodigiosus. |
| January, .   | 1,680,000                                        | 34                      | 35        | .28    | .0076    | .0086       | .23       | .0170       | .0000     | .31              | 79                             | 599                            | -                     |
| February, .  | 1,780,000                                        | 35                      | 35        | .30    | .0084    | .0112       | .22       | .0215       | .0000     | .35              | 78                             | 188                            | -                     |
| March, .     | 1,980,000                                        | 35                      | 35.5      | .29    | .0032    | .0084       | .18       | .0207       | .0000     | .34              | 82                             | 38                             | -                     |
| April, .     | 1,540,000                                        | 39                      | 41        | .37    | .0018    | .0102       | .11       | .0135       | .0000     | .38              | 73                             | 17                             | -                     |
| May, .       | 1,900,000                                        | 53                      | 55.5      | .39    | .0011    | .0104       | .10       | .0250       | .0000     | .39              | 68                             | 12                             | 1.5                   |
| June, .      | 1,660,000                                        | 67                      | 69        | .30    | .0015    | .0090       | .16       | .0360       | .0000     | .29              | 43                             | 17                             | 1.2                   |
| July, .      | 1,940,000                                        | 72                      | 70        | .20    | .0024    | .0095       | .20       | .0307       | .0005     | .22              | 21                             | 127                            | 5.0                   |
| August, .    | 2,540,000                                        | 72                      | 70.5      | .16    | .0023    | .0090       | .20       | .0240       | .0000     | .16              | 27                             | 84                             | 3.3                   |
| September, . | 1,940,000                                        | 65                      | 63        | .12    | .0016    | .0079       | .22       | .0310       | .0000     | .14              | 60                             | 22                             | 0.7                   |
| October, .   | 1,980,000                                        | 57                      | 55        | .30    | .0025    | .0115       | .23       | .0237       | .0000     | .37              | 47                             | 29                             | 0.1                   |
| November, .  | 3,380,000                                        | 42                      | 42        | .33    | .0028    | .0124       | .19       | .0225       | .0000     | .37              | 83                             | 58                             | 4.5                   |
| December, .  | 3,900,000                                        | 34                      | 35.5      | .38    | .0054    | .0112       | .20       | .0190       | .0000     | .41              | 82                             | 60                             | 2.2                   |

**FILTER No. 39.**

The filter contained sand of an effective size of 0.20 millimeter. Its depth on the date of its construction, April 28, 1892, was 12 inches. It was operated continuously up to Aug. 19, 1893, the date of its discontinuance, with the exception of July 10 to 30, when it was operated intermittently with the outlet untrapped and wide open. The depth of sand May 1, 1893, was 2.5 inches. From May 12 to August 19 the surface was scraped 14 times to relieve clogging, and the average depth removed was 0.15 inch. The average quantity of water filtered between scrapings was equivalent to 13 million gal-

lons per acre. It was scraped on an average once in 7 days, and the sand removed was equivalent to 1.55 cubic yards per million gallons.

The depth of sand in the filter at the time the experiment was brought to an end was about 0.5 inch. In addition to this, however, there were 5 inches of underdrains, some of the material of which was fairly fine.

*Monthly Averages of Analyses of Effluent of Filter No. 39.*

[Parts per 100,000.]

| DATE — 1893. | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | BACTERIA PER CUBIC CENTIMETER. |                       |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|-----------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                | Water Bacteria.                | Bacillus Prodigiosus. |
| January, .   | 1,620,000                                        | 34                      | 35        | .26    | .0076    | .0112       | .24       | .0180       | .0000     | .33              | 79                             | 893                            | -                     |
| February, .  | 1,780,000                                        | 35                      | 35.3      | .30    | .0082    | .0107       | .22       | .0210       | .0000     | .36              | 86                             | 251                            | -                     |
| March, .     | 1,900,000                                        | 35                      | 34.7      | .31    | .0053    | .0102       | .18       | .0220       | .0000     | .38              | 84                             | 63                             | -                     |
| April, .     | 1,540,000                                        | 39                      | 41.5      | .37    | .0037    | .0107       | .11       | .0120       | .0000     | .38              | 85                             | 18                             | -                     |
| May, .       | 1,980,000                                        | 53                      | 55.5      | .39    | .0017    | .0104       | .10       | .0220       | .0000     | .42              | 50                             | 19                             | 4                     |
| June, .      | 1,580,000                                        | 67                      | 69        | .31    | .0010    | .0091       | .16       | .0300       | .0000     | .32              | 38                             | 35                             | 9                     |
| July, .      | 1,480,000                                        | 72                      | 73        | .22    | .0019    | .0142       | .21       | .0270       | .0000     | .26              | 62                             | 352                            | 82                    |
| August, .    | 1,740,000                                        | 72                      | 70.2      | .19    | .0019    | .0120       | .20       | .0230       | .0000     | .19              | 55                             | 318                            | 89                    |

**FILTER No. 41.**

This filter, a duplicate of No. 33 A, was constructed May 9, 1892, and contained originally 60 inches in depth of sand of an effective size of 0.14 millimeter. It has been operated intermittently, except from April 17 to 30, with the outlet untrapped. On July 17 the upper foot of material was dug out and put back (see page 465). Up to Oct. 1, 1893, the faucet at the outlet was kept wide open and the rate of filtration regulated at the top. During the rest of the year, except November 21 to 30, it was operated as follows: the faucet at the outlet was closed at 5 A.M. daily, after the filter had been allowed to drain over night, and the water applied at the top; after the surface was covered the faucet was opened at the outlet to give the desired rate of filtration, and the surface was kept covered until the water was shut off at 9 P.M.

From May 12 to December 8 the surface was scraped 8 times to



relieve clogging, — an average of once in 22 days. The average depth removed at a scraping was 0.19 inch; the average quantity of water filtered between scrapings was equivalent to 56 million gallons per acre; and the sand removed was equivalent to 0.46 cubic yard per million gallons.

Until Nov. 15, 1893, the sand removed by scraping was not replaced with new material, but on that date the depth was restored from 52 inches to its original depth of 60 inches. After this date the sand was replaced at the time of scraping.

*Monthly Averages of Analyses of Effluent of Filter No. 41.*

[Parts per 100,000.]

| DATE — 1893. | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | BACTERIA PER CUBIC CENTIMETER. |                       |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|-----------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                | Water Bacteria.                | Bacillus Prodigiosus. |
| January, .   | 1,660,000                                        | 34                      | 37        | .26    | .0050    | .0094       | .23       | .0170       | .0000     | .32              | 99                             | 508                            | -                     |
| February, .  | 1,660,000                                        | 35                      | 37        | .28    | .0088    | .0091       | .23       | .0285       | .0000     | .28              | 99                             | 280                            | -                     |
| March, .     | 1,500,000                                        | 35                      | 39.5      | .28    | .0045    | .0080       | .17       | .0180       | .0000     | .32              | 100                            | 64                             | -                     |
| April, .     | 1,840,000                                        | 39                      | 45        | .33    | .0005    | .0083       | .11       | .0140       | .0000     | .33              | 95                             | 26                             | -                     |
| May, .       | 2,060,000                                        | 53                      | 58        | .39    | .0017    | .0095       | .10       | .0134       | .0000     | .39              | 89                             | 9                              | 1.5                   |
| June, .      | 1,460,000                                        | 67                      | 69.8      | .30    | .0014    | .0104       | .16       | .0255       | .0000     | .30              | 51                             | 10                             | 1.5                   |
| July, .      | 2,020,000                                        | 72                      | 73.5      | .21    | .0027    | .0105       | .20       | .0407       | .0000     | .22              | 91                             | 33                             | 4.4                   |
| August, .    | 1,900,000                                        | 72                      | 68.7      | .17    | .0018    | .0097       | .20       | .0364       | .0000     | .16              | 79                             | 39                             | 5.4                   |
| September, . | 1,940,000                                        | 65                      | 65        | .24    | .0019    | .0105       | .21       | .0267       | .0000     | .30              | 86                             | 48                             | 2.9                   |
| October, .   | 1,800,000                                        | 57                      | 55.8      | .24    | .0021    | .0099       | .24       | .0254       | .0000     | .29              | 94                             | 19                             | 0.5                   |
| November, .  | 1,560,000                                        | 42                      | 45.6      | .33    | .0019    | .0115       | .18       | .0237       | .0000     | .40              | 93                             | 10                             | 0.3                   |
| December, .  | 1,200,000                                        | 34                      | 35.5      | .36    | .0024    | .0114       | .20       | .0270       | .0000     | .39              | 96                             | 26                             | 1.6                   |

**FILTER NO. 42.**

This filter was started on Oct. 29, 1892, and contained 13 inches in depth of sand of an effective size of 0.20 millimeter. It has been operated continuously in the usual manner. The depth of sand in May, 1893, was 10 inches.

From May 12 to December 8 the surface was scraped 24 times to relieve clogging. It was scraped on an average once in 7 days. The average depth removed was 0.16 inch; the average quantity of water filtered between scrapings was equivalent to 19 million gal-

lons per acre; and the sand removed was equivalent to 1.11 cubic yards per million gallons.

The sand removed by scraping was not replaced with clean material until September 9. The depth of sand was then about 7 inches, and the filter was refilled to its original depth. From this time on the sand was replaced at the time of scraping. The addition of new material in September caused a greater (percentage) removal of color.

*Monthly Averages of Analyses of Effluent of Filter No. 42.*

[Parts per 100,000.]

| DATE—1893.   | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | BACTERIA PER CUBIC CENTIMETER. |                        |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|------------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                | Water Bacteria.                | Bacillus Prodigiousus. |
| January, .   | 1,680,000                                        | 34                      | 36        | .30    | .0068    | .0114       | .23       | .0150       | .0000     | .43              | 85                             | 397                            | -                      |
| February, .  | 1,740,000                                        | 35                      | 35        | .30    | .0080    | .0105       | .22       | .0205       | .0000     | .34              | 80                             | 94                             | -                      |
| March, .     | 1,920,000                                        | 35                      | 35        | .31    | .0056    | .0107       | .16       | .0190       | .0000     | .36              | 85                             | 21                             | -                      |
| April, .     | 1,560,000                                        | 39                      | 42        | .37    | .0027    | .0108       | .11       | .0160       | .0000     | .35              | 85                             | 18                             | -                      |
| May, .       | 1,920,000                                        | 53                      | 55.5      | .41    | .0006    | .0100       | .10       | .0190       | .0000     | .41              | 74                             | 9                              | 1.5                    |
| June, .      | 1,660,000                                        | 67                      | 69        | .30    | .0021    | .0095       | .16       | .0310       | .0000     | .32              | 63                             | 10                             | 1.5                    |
| July, .      | 1,920,000                                        | 72                      | 71        | .23    | .0027    | .0103       | .21       | .0312       | .0002     | .23              | 11                             | 117                            | 5.5                    |
| August, .    | 1,860,000                                        | 72                      | 69        | .14    | .0018    | .0083       | .20       | .0247       | .0004     | .17              | 42                             | 55                             | 2.8                    |
| September, . | 1,780,000                                        | 65                      | 64        | .15    | .0016    | .0007       | .22       | .0255       | .0000     | .22              | 56                             | 22                             | 2.8                    |
| October, .   | 1,980,000                                        | 57                      | 55        | .32    | .0018    | .0121       | .23       | .0223       | .0000     | .39              | 54                             | 13                             | 1.4                    |
| November, .  | 1,880,000                                        | 42                      | 43.5      | .31    | .0022    | .0109       | .19       | .0240       | .0000     | .36              | 81                             | 78                             | 7.0                    |
| December, .  | 2,000,000                                        | 34                      | 35.5      | .37    | .0030    | .0114       | .20       | .0240       | .0000     | .41              | 82                             | 83                             | 6.0                    |

**FILTER No. 43.**

This filter was started on May 20, 1893, and contained 60 inches in depth of sand of an effective size of 0.26 millimeter. It has been operated continuously.

From May 20 to December 8 it was scraped 16 times. This was an average of once in 10 days. The average depth removed was 0.26 inch, and the average quantity of water filtered between scrapings was equivalent to 57 million gallons per acre. The sand removed was equivalent to 0.63 cubic yard per million gallons.

The sand removed up to October 13 was replaced with clean material on that date, and after that time the sand was replaced at the time of scraping.

*Monthly Averages of Analyses of Effluent of Filter No. 43.*

[Parts per 100,000.]

| DATE — 1893. | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | BACTERIA PER CUBIC CENTIMETER. |                       |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|-----------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                | Water Bacteria.                | Bacillus prodigiosus. |
| May, . . .   | 2,200,000                                        | 53                      | 56        | .45    | .0028    | .0109       | .15       | .0160       | .0000     | .29              | 100                            | 1,042                          | 53.0                  |
| June, . . .  | 3,920,000                                        | 67                      | 66        | .33    | .0025    | .0109       | .18       | .0257       | .0000     | .29              | 74                             | 316                            | 6.0                   |
| July, . . .  | 2,820,000                                        | 72                      | 69        | .20    | .0020    | .0111       | .20       | .0290       | .0000     | .23              | 29                             | 72                             | 5.5                   |
| August, . .  | 4,260,000                                        | 72                      | 67        | .14    | .0015    | .0098       | .20       | .0245       | .0000     | .17              | 33                             | 26                             | 5.0                   |
| September, . | 4,540,000                                        | 65                      | 65        | .32    | .0015    | .0112       | .22       | .0263       | .0000     | .39              | 49                             | 57                             | 2.4                   |
| October, . . | 4,820,000                                        | 57                      | 57        | .26    | .0022    | .0113       | .24       | .0264       | .0000     | .30              | 60                             | 46                             | 8.4                   |
| November, .  | 7,600,000                                        | 42                      | 44        | .35    | .0064    | .0119       | .18       | .0213       | .0000     | .41              | 81                             | 124                            | 11.0                  |
| December, .  | 9,340,000                                        | 34                      | 35        | .41    | .0098    | .0144       | .20       | .0180       | .0000     | .48              | 86                             | 1,165                          | 60.0                  |

## FILTER NO. 44.

This filter was put in operation, continuously, May 20, 1893, and contained 60 inches in depth of sand of an effective size of 0.29 millimeter. The sand removed by scraping up to October 27 was replaced on that date, and after that time the sand was replaced with clean material at the time of its removal.

From May 20 to December 8 the surface was scraped 13 times to relieve clogging, and the average depth removed was 0.30 inch. The average quantity of water filtered between scrapings was equivalent to 70 million gallons per acre. It was scraped on an average once in 13 days, and the sand removed was equivalent to 0.58 cubic yard per million gallons.

*Monthly Averages of Analyses of Effluent of Filter No. 44.*

[Parts per 100,000.]

| DATE — 1893. | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | BACTERIA PER CUBIC CENTIMETER. |                       |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|-----------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                | Water Bacteria.                | Bacillus prodigiosus. |
| May, . . .   | 2,200,000                                        | 53                      | 56        | .45    | .0036    | .0113       | .14       | .0160       | .0000     | .32              | 93                             | 318                            | 57.0                  |
| June, . . .  | 2,840,000                                        | 67                      | 66        | .35    | .0018    | .0106       | .17       | .0252       | .0000     | .29              | 75                             | 123                            | 12.0                  |
| July, . . .  | 2,820,000                                        | 72                      | 69        | .23    | .0017    | .0108       | .20       | .0285       | .0005     | .23              | 38                             | 29                             | 7.0                   |
| August, . .  | 4,340,000                                        | 72                      | 67        | .14    | .0019    | .0097       | .20       | .0400       | .0000     | .16              | 69                             | 29                             | 6.0                   |
| September, . | 4,660,000                                        | 65                      | 66        | .32    | .0019    | .0116       | .21       | .0257       | .0000     | .36              | 46                             | 53                             | 1.3                   |
| October, . . | 5,840,000                                        | 57                      | 57        | .26    | .0026    | .0110       | .24       | .0274       | .0000     | .31              | 71                             | 22                             | 1.9                   |
| November, .  | 7,620,000                                        | 42                      | 44        | .35    | .0055    | .0122       | .18       | .0197       | .0000     | .41              | 80                             | 96                             | 9.0                   |
| December, .  | 9,300,000                                        | 34                      | 35.5      | .40    | .0094    | .0138       | .20       | .0190       | .0000     | .46              | 83                             | 326                            | 29.0                  |

## FILTER No. 45.

This filter was constructed July 10, 1893, and contained 60 inches in depth of sand of an effective size of 0.23 millimeter. It has been operated intermittently after the same method that was used in the case of No. 41 (see page 503). With respect to size of sand grains it resembles most closely the continuous filter No. 43.

From July 10 to December 8 the surface was scraped 4 times. This was an average of once in 35 days. The average depth removed was 0.28 inch, and the average quantity of water filtered between scrapings was equivalent to 78 million gallons per acre. The sand removed was equivalent to 0.48 cubic yards per million gallons.

The sand removed up to October 27 was replaced with clean material on that date, and after that time the sand was replaced at the time of scraping.

*Monthly Averages of Analyses of Effluent of Filter No. 45.*

[Parts per 100,000.]

| DATE — 1893. | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | BACTERIA PER CUBIC CENTIMETER. |                       |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|-----------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                | Water Bacteria.                | Bacillus Prodigiosus. |
| July, . . .  | 1,500,000                                        | 72                      | 73        | .30    | .0025    | .0130       | .22       | .0243       | .0000     | .22              | 97                             | 680                            | 92                    |
| August, . .  | 1,920,000                                        | 72                      | 72        | .16    | .0021    | .0100       | .20       | .0258       | .0000     | .17              | 95                             | 92                             | 25                    |
| September, . | 1,740,000                                        | 65                      | 66        | .37    | .0022    | .0147       | .21       | .0227       | .0000     | .44              | 93                             | 725                            | 8                     |
| October, . . | 1,800,000                                        | 57                      | 58        | .24    | .0018    | .0115       | .24       | .0275       | .0000     | .25              | 93                             | 39                             | 12                    |
| November, .  | 3,560,000                                        | 42                      | 43        | .36    | .0034    | .0122       | .19       | .0170       | .0000     | .41              | 97                             | 119                            | 12                    |
| December, .  | 5,760,000                                        | 34                      | 35        | .42    | .0084    | .0148       | .20       | .0180       | .0000     | .47              | 98                             | 621                            | 34                    |

## FILTER No. 46.

This filter was put in operation Aug. 21, 1893, and contained 12 inches of sand of an effective size of 0.29 millimeter. This sand was from the same lot as that used for No. 44. It has been operated continuously. From August 21 to December 8 the surface was scraped 9 times to relieve clogging, and the average depth removed was 0.25 inch. The average quantity of water filtered between scrapings was equivalent to 29 million gallons per acre. It was scraped on an average once in 11 days, and the sand removed was equivalent to 1.16 cubic yards per million gallons.

*Monthly Averages of Analyses of Effluent of Filter No. 46.*

[Parts per 100,000.]

| DATE - 1893. | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | BACTERIA PER CUBIC CENTIMETER. |                       |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|-----------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                | Water Bacteria.                | Bacillus Prodigiosus. |
| August, .    | 2,040,000                                        | 72                      | 68        | .20    | .0029    | .0120       | .20       | .0245       | .0000     | .20              | 55                             | 65                             | 1.3                   |
| September, . | 1,920,000                                        | 65                      | 64        | .28    | .0014    | .0130       | .22       | .0255       | .0000     | .35              | 49                             | 98                             | 3.3                   |
| October, .   | 2,260,000                                        | 57                      | 57        | .22    | .0021    | .0106       | .24       | .0270       | .0000     | .26              | 57                             | 41                             | 18.0                  |
| November, .  | 3,600,000                                        | 42                      | 43        | .39    | .0050    | .0127       | .20       | .0183       | .0000     | .47              | 81                             | 171                            | 17.0                  |
| December, .  | 4,180,000                                        | 34                      | 35        | .37    | .0092    | .0126       | .20       | .0180       | .0000     | .46              | 85                             | 254                            | 18.0                  |

## FILTER No. 47.

This filter was put in operation Sept. 8, 1893, and contained 60 inches in depth of sand of an effective size of 0.29 millimeter. The sand was of the same size and from the same lot as that of No. 44. It has been operated intermittently in the same manner as No. 41 (see page 503).

From September 8 to December 8 it was scraped twice, an average of once in 42 days. The average depth removed was 0.45 inch, and the average quantity of water filtered between scrapings was equivalent to 100 million gallons per acre. The sand removed was equivalent to 0.60 cubic yard per million gallons.

*Monthly Averages of Analyses of Effluent of Filter No. 47.*

[Parts per 100,000.]

| DATE - 1893. | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | BACTERIA PER CUBIC CENTIMETER. |                       |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|-----------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                | Water Bacteria.                | Bacillus Prodigiosus. |
| September, . | 1,740,000                                        | 65                      | 64        | .33    | .0027    | .0144       | .22       | .0150       | .0001     | .35              | 99                             | 2,296                          | 176                   |
| October, .   | 1,800,000                                        | 57                      | 56        | .28    | .0018    | .0134       | .24       | .0215       | .0003     | .27              | 99                             | 598                            | 18                    |
| November, .  | 3,580,000                                        | 42                      | 44        | .41    | .0026    | .0138       | .19       | .0182       | .0002     | .45              | 97                             | 213                            | 25                    |
| December, .  | 6,360,000                                        | 34                      | 35.5      | .40    | .0072    | .0144       | .20       | .0180       | .0010     | .47              | 95                             | 716                            | 46                    |

## FILTER No. 48.

This filter was put in operation Sept. 9, 1893, and contained 60 inches in depth of sand of an effective size of 0.38 millimeter. It has been operated intermittently in the same way as No. 41 (see page 503).

Up to December 8 it was scraped but once, — 71 days after it was first put in operation. The depth removed was 0.88 inch, which was equivalent to 0.66 cubic yard per million gallons of water. The quantity filtered up to the time of the scraping was equivalent to 181 million gallons per acre.

*Monthly Averages of Analyses of Effluent of Filter No. 48.*

[Parts per 100,000.]

| DATE—1893.   | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | BACTERIA PER CUBIC CENTIMETER. |                       |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|-----------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                | Water Bacteria.                | Bacillus Prodigiosus. |
| September, . | 1,760,000                                        | 65                      | 64        | .35    | .0029    | .0138       | .22       | .0145       | .0004     | .36              | 99                             | 3,050                          | 136                   |
| October, .   | 1,800,000                                        | 57                      | 57        | .30    | .0020    | .0132       | .24       | .0267       | .0000     | .26              | 100                            | 663                            | 33                    |
| November, .  | 2,920,000                                        | 42                      | 45        | .43    | .0026    | .0133       | .19       | .0172       | .0002     | .46              | 98                             | 123                            | 23                    |
| December, .  | 2,980,000                                        | 34                      | 36        | .40    | .0060    | .0146       | .20       | .0240       | .0006     | .46              | 100                            | 861                            | 46                    |

## FILTER No. 49.

This filter, a duplicate of No. 48, was put in operation Sept. 9, 1893. It has been operated continuously. Up to December 8 the surface was scraped 4 times, an average of once in 37 days. The average depth removed was 0.32 inch, and the average quantity of water filtered between scrapings was equivalent to 79 million gallons per acre. The sand removed was equivalent to 0.53 cubic yard per million gallons.

*Monthly Averages of Analyses of Effluent of Filter No. 49.*

[Parts per 100,000.]

| DATE — 1893. | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | BACTERIA PER CUBIC CENTIMETER. |                       |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|-----------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                | Water Bacteria.                | Bacillus Prodigiosus. |
| September, . | 2,060,000                                        | 65                      | 62        | .33    | .0029    | .0142       | .22       | .0165       | .0000     | .31              | 69                             | 344                            | 19                    |
| October, .   | 2,600,000                                        | 57                      | 57        | .26    | .0013    | .0102       | .24       | .0265       | .0000     | .26              | 61                             | 112                            | 7                     |
| November, .  | 5,260,000                                        | 42                      | 44        | .41    | .0038    | .0132       | .19       | .0170       | .0001     | .45              | 88                             | 72                             | 12                    |
| December, .  | 5,600,000                                        | 34                      | 36        | .41    | .0070    | .0138       | .20       | .0230       | .0002     | .46              | 89                             | 163                            | 7                     |

## FILTERS NOS. 3 B AND 8 A.

These filters are each one two-hundredth of an acre in area, and contain 5 feet in depth of sand of an effective size of 0.23 millimeter. This sand was taken from the same place as that which was used in the construction of the Lawrence city filter, and in size it is very similar to a large proportion of the sand in the city filter. The maximum rate at which this sand will allow water to pass, when the acting head is equal to the depth of the sand, is estimated at 43,000,000 gallons per acre daily. The maximum loss of head in the case of each filter is about 73 inches.

Filter No. 3 B has been operated intermittently since Sept. 23, 1893, as follows: at 5 A.M. the gate on the outlet pipe, to which no trap has been attached, was closed, and the water turned on at the top, near the edge. When the filter was covered (about 7.30 A.M.) the gate on the outlet pipe was opened to give the prescribed rate of filtration, and the surface was kept covered until 9 P.M., when the water was shut off and the filter allowed to drain during the night. The filter has been operated in this manner six days in a week, and allowed to rest, after draining, on the seventh day. The rate of flow was 10 gallons per minute for about 16 hours during the day. This rate is equivalent to 2,880,000 gallons per acre daily (24 hours). In addition to the quantity of effluent obtained at this rate for 16 hours daily there is the daily drainage of the water held in the pores of the sand, equivalent to about 400,000 gallons per acre. On Feb. 27, 1894, the rate was reduced from 10 to 8 gallons per minute, owing to a lack of water supplied by the inlet pipe. The total

quantity of effluent yielded up to May 1, 1894, was equivalent to 356,191,100 gallons per acre, which is an average daily rate of 1,650,000 gallons per acre, or 1,925,000 gallons for each of the six days weekly on which it was actually operated. The first occasion on which the filter failed to yield water at the prescribed rate was on December 19, when the total quantity of effluent was equivalent to 153,105,500 gallons per acre. The outlet gate was closed, with the surface covered, from 9.25 to 10.25 A.M., during which time the air that had been held in the pores of the sand bubbled up through the surface and caused the water level to drop 5 inches. This treatment was repeated on Dec. 24, 1893, Jan. 13, 15, 16 and 17, 1894. Ice was removed from the surface, in order to facilitate the displacement of air by water within the filter, as follows: January 4, 2 to 8 inches; January 16, 4 inches; February 26, 6 inches. The ice was broken along the edges on January 15, when it was 6 inches thick. The filter was drained every night, and from 1 to 3 inches of frost frequently appeared at the surface and caused an unfavorable effect upon the removal of bacteria and upon nitrification during the winter months (see pages 468 and 481). On Jan. 31, 1894, a wooden conduit, similar to the lateral conduits at the Lawrence city filter, was placed across the middle of the surface to aid in the distribution of the water. The filter was scraped about 0.6 of an inch deep on March 17, 1894, and the surface ridged; the depth of sand at the sides, at right angles to the conduit, was increased 6 inches, and the surface graded off toward the centre, somewhat similar to the arrangement of the surface of the Lawrence city filter. It was not necessary to scrape the surface at this time to relieve clogging, as the loss of head was only 18.5 inches on this date. The total quantity of effluent up to this time was equivalent to 295,226,500 gallons per acre. The discolored and partially clogged sand removed was equal to 0.27 cubic yard per million gallons. The reason that this filter yielded so much more water without scraping than No. 8 A, its continuous mate, was that the method of operation practised caused a disturbance of the accumulating sediment on the surface. The effect of this was also felt in the bacterial results, as will be seen beyond.

In the tables on the pages beyond are presented the daily results obtained from Filters Nos. 3 B and 8 A, and in the foot-notes mention is made of all special features in the operation of the filters.

Filter No. 8 A has been operated continuously since September 26 at the rate of 7 gallons per minute, equivalent to 2,016,000 gal-



lons per acre daily. The rate of filtration, which is controlled by a gate on the outlet pipe to which no trap was attached, was reduced on February 27 to 5 gallons per minute, owing to a reduction in the quantity of water delivered by the inlet pipe. The total quantity of effluent yielded up to May 1, 1894, was equivalent to 359,850,300 gallons per acre, which is an average daily rate of 1,660,000 gallons per acre. During this period the surface was scraped six times, as follows: October 24, November 13, December 2, February 21, March 17 and April 23. The depth removed in each case was about 0.3 of an inch, which is equivalent to 0.70 cubic yard per million gallons on an average. The average quantity of water yielded between scrapings to relieve clogging was 58,200,000 gallons per acre; the minimum, 36,900,000 gallons; and the maximum, 147,600,000 gallons per acre. The average number of days between scrapings was 35, the minimum 19 and the maximum 81. During the latter period (December 2 to February 21) the filter became clogged seven times, as follows: December 29, January 16, 26 and 29, February 10, 12 and 19. On each occasion the prescribed quantity of water failed to pass through the filter with the gate on the outlet pipe wide open. The pores of the sand at these times contained considerable air; how much of it was evolved by the water is not definitely known, but it appears now that the greater part came through the untrapped outlet pipe, which was only partly filled with water on these days. By shutting the gate on the outlet pipe the air rose to the surface and disturbed the layer of accumulated sediment sufficiently to allow filtration to proceed for some days. To facilitate the displacement of air within the pores by water the ice was removed as follows: December 29, 3 to 8 inches; January 16, 2 to 8.5 inches; January 29, 6 inches; February 12, 3 to 6.5 inches; February 21, 2 to 6 inches. The ice was broken along the edge on February 10 and 19. The space above the top of the sand was 9 inches. It is probable that scraping could have been considerably longer postponed by continuing this method of treatment. The filter was scraped on March 17 for the sake of getting conditions for experiments comparable with those in No. 3 B. The filter was not clogged on that date. Neither filter was at any time protected from the weather.

The monthly averages of the results of chemical and bacterial analyses, which have already been discussed, are presented in the following tables:—

*Monthly Averages of Analyses of Merrimack River Water taken from the Canal and applied to Filters Nos. 3 B and 8 A.*

[Parts per 100,000.]

| DATE.            | Temperature.<br>Degrees F. | Color. | AMMONIA. |             |          | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Per Cent. of Dis-<br>solved Oxygen. | Hardness. | Bacteria per Cubic<br>Centimeter. |
|------------------|----------------------------|--------|----------|-------------|----------|-----------|----------------|-----------|------------------|-------------------------------------|-----------|-----------------------------------|
|                  |                            |        | Free.    | ALBUMINOID. |          |           | Nitrates.      | Nitrites. |                  |                                     |           |                                   |
|                  |                            |        |          | Total.      | Soluble. |           |                |           |                  |                                     |           |                                   |
| 1893.            |                            |        |          |             |          |           |                |           |                  |                                     |           |                                   |
| September, . . . | 63                         | .33    | .0108    | .0161       | -        | .22       | .0130          | .0003     | .39              | 83                                  | -         | 30,200                            |
| October, . . .   | 57                         | .34    | .0110    | .0201       | -        | .24       | .0120          | .0003     | .37              | 86                                  | -         | 16,500                            |
| November, . . .  | 42                         | .47    | .0071    | .0194       | -        | .19       | .0120          | .0001     | .53              | 97                                  | -         | 7,300                             |
| December, . . .  | 34                         | .44    | .0057    | .0177       | -        | .20       | .0150          | .0000     | .40              | 98                                  | -         | 9,800                             |
| 1894.            |                            |        |          |             |          |           |                |           |                  |                                     |           |                                   |
| January, . . .   | 33                         | .43    | .0055    | .0164       | .0141    | .21       | .0150          | .0001     | .41              | 88                                  | 1.5       | 6,700                             |
| February, . . .  | 34                         | .40    | .0068    | .0160       | .0148    | .22       | .0180          | .0001     | .42              | 94                                  | 1.6       | 8,000                             |
| March, . . .     | 37                         | .47    | .0040    | .0193       | .0172    | .15       | .0130          | .0001     | .46              | 100                                 | 1.0       | 10,100                            |
| April, . . .     | 47                         | .43    | .0027    | .0143       | .0125    | .15       | .0140          | .0000     | .41              | 95                                  | 1.3       | 11,500                            |

The bacterial samples in this and in the two following tables correspond as to time of collection to the chemical samples. The results of daily bacterial analyses will be found beyond.

*Monthly Averages of Analyses of Effluent of (Intermittent) Filter No. 3 B.*

[Parts per 100,000.]

| DATE.        | Quantity of Effluent.<br>Gallons per Acre Daily. | Temperature, Degrees F. | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dis- solved Oxygen. | Hardness. | Bacteria per Cubic Centimeter. |
|--------------|--------------------------------------------------|-------------------------|--------|----------|-------------|-----------|-------------|-----------|------------------|----------------------------------|-----------|--------------------------------|
|              |                                                  |                         |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                  |           |                                |
|              |                                                  |                         |        |          |             |           |             |           |                  |                                  |           |                                |
| 1893.        |                                                  |                         |        |          |             |           |             |           |                  |                                  |           |                                |
| September, . | 2,108,800                                        | 68                      | 1.35   | .0042    | .0158       | .22       | .0170       | .0000     | .19              | -                                | -         | 20,000                         |
| October, .   | 1,809,400                                        | 56                      | .35    | .0035    | .0139       | .24       | .0190       | .0012     | .29              | 97                               | -         | 2,700                          |
| November, .  | 1,868,400                                        | 41                      | .41    | .0022    | .0137       | .18       | .0220       | .0001     | .44              | 100                              | -         | 157                            |
| December, .  | 1,718,600                                        | 34                      | .38    | .0029    | .0121       | .20       | .0190       | .0000     | .42              | 100                              | -         | 237                            |
| 1894.        |                                                  |                         |        |          |             |           |             |           |                  |                                  |           |                                |
| January, .   | 1,592,200                                        | 33                      | .38    | .0021    | .0117       | .21       | .0250       | .0000     | .35              | 100                              | 1.5       | 194                            |
| February, .  | 1,454,700                                        | 33                      | .34    | .0018    | .0107       | .22       | .0270       | .0000     | .36              | 100                              | 1.6       | 197                            |
| March, .     | 1,482,600                                        | 37                      | .40    | .0014    | .0095       | .15       | .0180       | .0000     | .35              | 100                              | 1.0       | 165                            |
| April, .     | 1,497,500                                        | 48                      | .35    | .0011    | .0090       | .15       | .0200       | .0000     | .33              | 99                               | 1.4       | 83                             |

*Monthly Averages of Analyses of Effluent of (Continuous) Filter No. 8 A.*

[Parts per 100,000.]

| DATE.        | Quantity of Effluent.<br>Gallons per Acre Daily. | Temperature.<br>Degrees F. | Color. | AMMONIA. |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dis-<br>solved Oxygen. | Hardness. | Bacteria per Cubic<br>Centimeter. |
|--------------|--------------------------------------------------|----------------------------|--------|----------|------------|-----------|-------------|-----------|------------------|-------------------------------------|-----------|-----------------------------------|
|              |                                                  |                            |        | Free.    | Albuminoid |           | Nitrates.   | Nitrites. |                  |                                     |           |                                   |
| 1893.        |                                                  |                            |        |          |            |           |             |           |                  |                                     |           |                                   |
| September, . | 1,926,200                                        | 58                         | .55    | .0014    | .0122      | .22       | .0150       | .0000     | .22              | -                                   | -         | 10,400                            |
| October, .   | 1,780,500                                        | 56                         | .38    | .0053    | .0122      | .24       | .0180       | .0008     | .26              | 89                                  | -         | 1,000                             |
| November, .  | 1,808,500                                        | 41                         | .39    | .0018    | .0124      | .19       | .0200       | .0000     | .42              | 94                                  | -         | 125                               |
| December, .  | 1,966,400                                        | 34                         | .37    | .0021    | .0117      | .20       | .0220       | .0000     | .39              | 94                                  | -         | 135                               |
| 1894.        |                                                  |                            |        |          |            |           |             |           |                  |                                     |           |                                   |
| January, .   | 1,833,400                                        | 33                         | .37    | .0016    | .0115      | .21       | .0300       | .0000     | .35              | 89                                  | 1.5       | 72                                |
| February, .  | 1,455,900                                        | 33                         | .32    | .0017    | .0106      | .22       | .0310       | .0000     | .33              | 84                                  | 1.6       | 62                                |
| March, .     | 1,290,200                                        | 39                         | .39    | .0016    | .0102      | .16       | .0180       | .0000     | .34              | 93                                  | 1.0       | 71                                |
| April, .     | 1,371,400                                        | 47                         | .32    | .0014    | .0087      | .15       | .0210       | .0000     | .31              | 84                                  | 1.4       | 37                                |

*Monthly Averages of Bacterial Results from (Intermittent) Filter No. 3 B.*

| DATE.                                                      | Total<br>Quantity of<br>Effluent for Month.<br>—<br>Gallons per<br>Acre. | Bacteria<br>per Cubic<br>Centimeter<br>in Applied<br>Water. | BACTERIA PER CUBIC CENTIMETER IN<br>EFFLUENT. |         |        |        |
|------------------------------------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------------|-----------------------------------------------|---------|--------|--------|
|                                                            |                                                                          |                                                             | 8 A.M.                                        | 11 A.M. | 2 P.M. | 4 P.M. |
| 1893.                                                      |                                                                          |                                                             |                                               |         |        |        |
| October, . . . . .                                         | 65,887,000                                                               | 22,900                                                      | -                                             | 5,290   | 3,670  | -      |
| November, . . . . .                                        | 56,032,600                                                               | 7,900                                                       | 304                                           | 273     | 173    | 128    |
| December, . . . . .                                        | 53,275,300                                                               | 10,200                                                      | 308                                           | 280     | 238    | 251    |
| 1894.                                                      |                                                                          |                                                             |                                               |         |        |        |
| January, . . . . .                                         | 49,358,000                                                               | 7,100                                                       | 203                                           | 220     | 224    | 206    |
| February, . . . . .                                        | 40,731,400                                                               | 8,200                                                       | 230                                           | 214     | 146    | 171    |
| March, . . . . .                                           | 45,960,400                                                               | 7,700                                                       | 188                                           | 162     | 121    | 109    |
| April, . . . . .                                           | 44,926,400                                                               | 12,700                                                      | 148                                           | 134     | 88     | 74     |
| Averages, Nov.-April, inclusive, . . . . .                 |                                                                          | 9,000                                                       | 230                                           | 214     | 165    | 156    |
| Average per cent. in effluent of number applied, . . . . . |                                                                          | -                                                           | 2.56                                          | 2.38    | 1.83   | 1.73   |

The treatment of this filter on March 17, 1894, by which the surface was ridged in the manner already described, appeared to lessen the mechanical disturbance of the sand during the process of filling

the filter from the top, and thereby increase its bacterial efficiency. The average of the results given above show that during the period November to April, inclusive, this filter allowed 2.13 per cent. of the number of applied bacteria to pass through into the effluent. These results, however, cover only the first eight hours of each day's flow, and it has been learned that during the latter half of the flow (4 P.M. to midnight) the efficiency is practically the same or a very little greater than at 4 P.M. Averaging then the results obtained at 4 P.M. with the total average for the first half of the day (8 A.M. to 4 P.M.) we find that 1.93 per cent. of the number of applied bacteria passed through, — a removal of 98.07 per cent.

*Monthly Averages of Bacterial Results from (Continuous) Filter No. 8 A.*

| DATE.                                            | Total<br>Quantity of<br>Effluent for Month.<br><br>Gallons per<br>Acre. | Bacteria<br>per Cubic<br>Centimeter<br>in Applied<br>Water. | BACTERIA PER CUBIC CENTIMETER IN<br>EFFLUENT. |         |        |        |
|--------------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------|-----------------------------------------------|---------|--------|--------|
|                                                  |                                                                         |                                                             | 8 A.M.                                        | 11 A.M. | 2 P.M. | 4 P.M. |
| 1893.                                            |                                                                         |                                                             |                                               |         |        |        |
| October, . . . . .                               | 63,200,400                                                              | 23,000                                                      | -                                             | 2,540   | 3,200  | -      |
| November, . . . . .                              | 56,953,600                                                              | 7,900                                                       | 124                                           | 117     | 117    | 110    |
| December, . . . . .                              | 60,958,800                                                              | 10,200                                                      | 92                                            | 92      | 117    | 142    |
| 1894.                                            |                                                                         |                                                             |                                               |         |        |        |
| January, . . . . .                               | 56,835,600                                                              | 7,100                                                       | 70                                            | 79      | 80     | 88     |
| February, . . . . .                              | 40,765,200                                                              | 8,200                                                       | 83                                            | 76      | 73     | 72     |
| March, . . . . .                                 | 39,995,200                                                              | 7,700                                                       | 67                                            | 70      | 67     | 65     |
| April, . . . . .                                 | 41,141,500                                                              | 12,700                                                      | 40                                            | 40      | 41     | 42     |
| Averages, Nov.-April, inclusive, . . . . .       |                                                                         | 9,000                                                       | 79                                            | 79      | 83     | 86     |
| Average per cent. in effluent of number applied, |                                                                         | -                                                           | 0.88                                          | 0.88    | 0.92   | 0.95   |

Experiments upon this filter show that, under normal conditions, its efficiency in removing bacteria is substantially the same during the entire twenty-four hours. The averages given above include all results obtained and indicate that in some cases somewhat variable numbers were found in the effluent during the day. This is explained by the existence of some abnormal condition during a very few days in the month. The average results for the period, November to April, inclusive, show that the effluent contained 0.91 per cent. of the number of applied bacteria, — a removal of 99.09 per cent.

*Filter No. 3 B (Intermittent).*

| DATE—1893.              | Quantity of Effluent.<br>—<br>Gallons<br>per Acre Daily. | Bacteria per<br>Cubic<br>Centimeter<br>in<br>Applied Water. | BACTERIA PER CUBIC CENTIMETER<br>IN EFFLUENT. |        |
|-------------------------|----------------------------------------------------------|-------------------------------------------------------------|-----------------------------------------------|--------|
|                         |                                                          |                                                             | 11 A.M.                                       | 2 P.M. |
| September 27, . . . . . | 2,823,200                                                | 39,900                                                      | 12,800                                        | 13,800 |
| 28, . . . . .           | 2,024,200                                                | 64,800                                                      | 20,600                                        | 13,000 |
| 29, . . . . .           | 1,662,400                                                | 44,800                                                      | 36,600                                        | 18,600 |
| 30, . . . . .           | 2,285,600                                                | 79,800                                                      | 33,600                                        | 21,600 |
| October 1, . . . . .    | 0                                                        | —                                                           | —                                             | —      |
| 2, . . . . .            | 2,087,200                                                | 24,300                                                      | —                                             | 6,400  |
| 3, . . . . .            | 2,200,400                                                | 18,600                                                      | 3,300                                         | 1,500  |
| 4, . . . . .            | 2,188,000                                                | 20,200                                                      | 8,300                                         | 4,800  |
| 5, . . . . .            | 2,145,400                                                | 12,500                                                      | 4,100                                         | 2,400  |
| 6, . . . . .            | 2,259,000                                                | 13,800                                                      | 2,700                                         | 1,500  |
| 7, . . . . .            | 2,120,000                                                | 22,000                                                      | 4,200                                         | —      |
| 8, . . . . .            | 0                                                        | —                                                           | —                                             | —      |
| 9, . . . . .            | 2,205,800                                                | 8,600                                                       | 1,700                                         | 900    |
| 10, . . . . .           | 2,261,000                                                | 25,000                                                      | 3,000                                         | 1,200  |
| 11, . . . . .           | 2,080,000                                                | 45,600                                                      | 6,800                                         | 4,600  |
| 12, . . . . .           | 2,151,600                                                | 55,200                                                      | 2,100                                         | 2,000  |
| 13, . . . . .           | 2,186,800                                                | 34,200                                                      | 5,200                                         | —      |
| 14, . . . . .           | 2,088,400                                                | 51,300                                                      | 1,870                                         | —      |
| 15, . . . . .           | 0                                                        | —                                                           | —                                             | —      |
| 16, . . . . .           | 2,179,800                                                | 22,000                                                      | 1,200                                         | 420    |
| 17, . . . . .           | 2,242,600                                                | 16,200                                                      | 1,020                                         | 640    |
| 18, . . . . .           | 2,106,800                                                | 4,600                                                       | 450                                           | 210    |
| 19, . . . . .           | 2,292,000                                                | 5,200                                                       | 230                                           | 180    |
| 20, . . . . .           | 2,227,400                                                | 6,800                                                       | 760                                           | 120    |
| 21, . . . . .           | 2,329,000                                                | 6,300                                                       | 270                                           | 160    |
| 22, . . . . .           | 0                                                        | —                                                           | —                                             | —      |
| 23, . . . . .           | 2,260,000                                                | 1,900                                                       | 280                                           | 160    |
| 24, . . . . .           | 2,282,000                                                | 4,800                                                       | 230                                           | —      |
| 25, . . . . .           | 2,037,800                                                | 16,200                                                      | 480                                           | 120    |
| 26, . . . . .           | 2,262,000                                                | 20,700                                                      | 230                                           | 130    |
| 27, . . . . .           | 2,138,200                                                | 7,200                                                       | 540                                           | 330    |
| 28, . . . . .           | 2,235,800                                                | 7,100                                                       | 400                                           | 210    |
| 29, . . . . .           | 0                                                        | —                                                           | —                                             | —      |
| 30, . . . . .           | 2,265,400                                                | 6,000                                                       | 210                                           | 120    |
| 31, . . . . .           | 2,289,400                                                | 4,400                                                       | 180                                           | 160    |

The total quantity of effluent to the end of October was equivalent to 65,887,000 gallons per acre.

*Filter No. 8 A (Continuous).*

| DATE — 1893.            | Quantity<br>of Effluent.<br>Gallons<br>per Acre Daily. | Bacteria per<br>Cubic<br>Centimeter<br>in<br>Applied Water. | BACTERIA PER CUBIC CENTIMETER<br>IN EFFLUENT. |        |
|-------------------------|--------------------------------------------------------|-------------------------------------------------------------|-----------------------------------------------|--------|
|                         |                                                        |                                                             | 11 A.M.                                       | 2 P.M. |
| September 27, . . . . . | 1,671,400                                              | 39,900                                                      | 12,100                                        | 13,500 |
| 28, . . . . .           | 2,016,000                                              | 64,800                                                      | 18,700                                        | 24,000 |
| 29, . . . . .           | 1,961,400                                              | 44,800                                                      | 12,000                                        | 14,600 |
| 30, . . . . .           | 2,056,000                                              | 79,800                                                      | 6,900                                         | 15,000 |
| October 1, . . . . .    | 2,056,000                                              | —                                                           | —                                             | —      |
| 2, . . . . .            | 1,970,000                                              | 24,300                                                      | 3,300                                         | 4,400  |
| 3, . . . . .            | 2,002,000                                              | 18,600                                                      | 3,000                                         | 2,800  |
| 4, . . . . .            | 2,007,400                                              | 20,200                                                      | 2,700                                         | 3,800  |
| 5, . . . . .            | 2,030,000                                              | 12,500                                                      | 2,700                                         | 1,600  |
| 6, . . . . .            | 2,044,000                                              | 13,800                                                      | 3,000                                         | 2,200  |
| 7, . . . . .            | 630,000                                                | 22,000                                                      | 2,600                                         | —      |
| 8, . . . . .            | 0                                                      | —                                                           | —                                             | —      |
| 9, . . . . .            | 1,017,000                                              | 8,600                                                       | 1,040                                         | 530    |
| 10, . . . . .           | 1,894,800                                              | 25,000                                                      | 840                                           | 420    |
| 11, . . . . .           | 2,009,000                                              | 45,600                                                      | 1,700                                         | 720    |
| 12, . . . . .           | 2,002,000                                              | 55,200                                                      | 420                                           | 900    |
| 13, . . . . .           | 1,995,500                                              | 34,200                                                      | 430                                           | —      |
| 14, . . . . .           | 1,998,500                                              | 51,300                                                      | 190                                           | —      |
| 15, . . . . .           | 1,998,500                                              | —                                                           | —                                             | —      |
| 16, . . . . .           | 2,184,000                                              | 22,000                                                      | 190                                           | 180    |
| 17, . . . . .           | 1,925,600                                              | 16,200                                                      | 210                                           | 200    |
| 18, . . . . .           | 2,009,000                                              | 4,600                                                       | 120                                           | 130    |
| 19, . . . . .           | 1,927,200                                              | 5,200                                                       | 180                                           | 120    |
| 20, . . . . .           | 1,878,200                                              | 6,800                                                       | 190                                           | 220    |
| 21, . . . . .           | 1,947,200                                              | 6,300                                                       | 260                                           | 240    |
| 22, . . . . .           | 1,000,000                                              | —                                                           | —                                             | —      |
| 23, . . . . .           | 263,400                                                | 1,900                                                       | 220                                           | 290    |
| 24, . . . . .           | 1,673,000                                              | 4,800                                                       | —                                             | 180    |
| 25, . . . . .           | 2,044,000                                              | 16,200                                                      | 270                                           | 320    |
| 26, . . . . .           | 2,023,000                                              | 20,700                                                      | 130                                           | 140    |
| 27, . . . . .           | 2,009,000                                              | 7,200                                                       | 220                                           | 210    |
| 28, . . . . .           | 2,023,000                                              | 7,100                                                       | 190                                           | 190    |
| 29, . . . . .           | 2,023,000                                              | —                                                           | —                                             | —      |
| 30, . . . . .           | 2,016,000                                              | 6,000                                                       | 90                                            | 90     |
| 31, . . . . .           | 1,995,000                                              | 4,400                                                       | 150                                           | 120    |

The total quantity of effluent to the end of October was 63,200,400 gallons per acre.

The gate on the outlet pipe was closed October 7, 4 P.M., to October 9, 8 A.M.; and October 23, 8.40 to 11.35 A.M. On October 24 the surface was allowed to uncover, and was scraped between 10 and 12 A.M.

*Filter No. 3 B (Intermittent) — Continued.*

| DATE — 1893.      | Quantity<br>of Effluent.<br>—<br>Gallons per<br>Acre Daily. | Bacteria per<br>Cubic<br>Centimeter<br>in Applied<br>Water. | BACTERIA PER CUBIC CENTIMETER IN EFFLUENT. |         |        |        |
|-------------------|-------------------------------------------------------------|-------------------------------------------------------------|--------------------------------------------|---------|--------|--------|
|                   |                                                             |                                                             | 8 A.M.                                     | 11 A.M. | 2 P.M. | 4 P.M. |
| November 1, . . . | 2,293,000                                                   | 6,000                                                       | 336                                        | 300     | 164    | 110    |
| 2, . . .          | 2,185,800                                                   | 7,600                                                       | 276                                        | 384     | 187    | 170    |
| 3, . . .          | 2,251,000                                                   | 8,000                                                       | 100                                        | 240     | 198    | 110    |
| 4, . . .          | 2,186,400                                                   | 6,300                                                       | 102                                        | 240     | 144    | 110    |
| 5, . . .          | 0                                                           | —                                                           | —                                          | —       | —      | —      |
| 6, . . .          | 2,225,400                                                   | 7,300                                                       | 510                                        | 546     | 250    | 100    |
| 7, . . .          | 2,102,800                                                   | 5,200                                                       | 396                                        | 324     | 150    | 75     |
| 8, . . .          | 2,200,400                                                   | 4,400                                                       | 390                                        | 258     | 98     | 112    |
| 9, . . .          | 2,269,800                                                   | 4,600                                                       | 294                                        | 258     | 150    | 115    |
| 10, . . .         | 2,197,000                                                   | 5,600                                                       | 240                                        | 145     | 140    | 60     |
| 11, . . .         | 2,072,400                                                   | 5,100                                                       | 215                                        | 296     | 162    | 112    |
| 12, . . .         | 0                                                           | —                                                           | —                                          | —       | —      | —      |
| 13, . . .         | 2,252,200                                                   | 8,700                                                       | 351                                        | 321     | 100    | 120    |
| 14, . . .         | 1,978,000                                                   | 8,900                                                       | 294                                        | 243     | 170    | 103    |
| 15, . . .         | 1,986,000                                                   | 4,700                                                       | 180                                        | 128     | 57     | 97     |
| 16, . . .         | 2,217,400                                                   | 6,900                                                       | 210                                        | 208     | 120    | 65     |
| 17, . . .         | 2,101,000                                                   | 6,300                                                       | 170                                        | 248     | 114    | 98     |
| 18, . . .         | 2,270,400                                                   | 6,700                                                       | 240                                        | 221     | 105    | 62     |
| 19, . . .         | 0                                                           | —                                                           | —                                          | —       | —      | —      |
| 20, . . .         | 2,145,600                                                   | 8,900                                                       | 400                                        | 216     | 120    | 140    |
| 21, . . .         | 2,071,200                                                   | 8,200                                                       | 180                                        | 60      | 150    | 145    |
| 22, . . .         | 2,185,600                                                   | 8,200                                                       | 132                                        | 180     | 117    | 110    |
| 23, . . .         | 2,110,600                                                   | 18,300                                                      | 240                                        | 190     | 105    | 89     |
| 24, . . .         | 2,105,200                                                   | 10,100                                                      | 246                                        | 270     | 252    | 100    |
| 25, . . .         | 2,170,800                                                   | 11,500                                                      | 396                                        | 360     | 300    | 300    |
| 26, . . .         | 0                                                           | —                                                           | —                                          | —       | —      | —      |
| 27, . . .         | 2,259,200                                                   | 10,500                                                      | 600                                        | 480     | 140    | 124    |
| 28, . . .         | 1,992,000                                                   | 9,100                                                       | 420                                        | 480     | 629    | 429    |
| 29, . . .         | 2,095,600                                                   | 12,300                                                      | 450                                        | 230     | 260    | 140    |
| 30, . . .         | 2,127,800                                                   | 6,800                                                       | 534                                        | —       | —      | —      |

Quantity of effluent for month was 56,052,600 gallons per acre.

*Filter No. 8 A (Continuous)* — Continued.

| DATE — 1893.      | Quantity of Effluent.<br>Gallons per Acre Daily. | Bacteria per Cubic Centimeter in Applied Water. | BACTERIA PER CUBIC CENTIMETER IN EFFLUENT. |         |        |        |
|-------------------|--------------------------------------------------|-------------------------------------------------|--------------------------------------------|---------|--------|--------|
|                   |                                                  |                                                 | 8 A.M.                                     | 11 A.M. | 2 P.M. | 4 P.M. |
| November 1, . . . | 2,023,000                                        | 6,000                                           | 210                                        | 56      | 58     | 96     |
| 2, . . .          | 1,988,000                                        | 7,600                                           | 170                                        | 123     | 180    | 180    |
| 3, . . .          | 2,051,000                                        | 8,000                                           | 130                                        | 150     | 164    | 108    |
| 4, . . .          | 2,002,000                                        | 6,300                                           | 97                                         | 75      | 121    | 55     |
| 5, . . .          | 2,002,000                                        | -                                               | -                                          | -       | -      | -      |
| 6, . . .          | 1,985,400                                        | 7,300                                           | 46                                         | 92      | 95     | 75     |
| 7, . . .          | 1,955,800                                        | 5,200                                           | 125                                        | 120     | 120    | 112    |
| 8, . . .          | 2,027,200                                        | 4,400                                           | 65                                         | 91      | 62     | 76     |
| 9, . . .          | 1,829,600                                        | 4,600                                           | 110                                        | 100     | 114    | 125    |
| 10, . . .         | 1,685,600                                        | 5,600                                           | 110                                        | 130     | 184    | 216    |
| 11, . . .         | 1,000,000                                        | 5,100                                           | 185                                        | 275     | 279    | 240    |
| 12, . . .         | 348,400                                          | -                                               | -                                          | -       | -      | -      |
| 13, . . .         | 1,663,200                                        | 8,700                                           | 559                                        | 342     | 310    | 378    |
| 14, . . .         | 2,002,000                                        | 8,900                                           | 270                                        | 240     | 105    | 90     |
| 15, . . .         | 2,016,000                                        | 4,700                                           | 130                                        | 123     | 160    | 91     |
| 16, . . .         | 2,001,400                                        | 6,900                                           | 140                                        | 127     | 110    | 104    |
| 17, . . .         | 2,016,000                                        | 6,300                                           | 97                                         | 70      | 100    | 70     |
| 18, . . .         | 2,026,500                                        | 6,700                                           | 106                                        | 107     | 70     | 87     |
| 19, . . .         | 2,026,500                                        | -                                               | -                                          | -       | -      | -      |
| 20, . . .         | 2,034,200                                        | 8,900                                           | 110                                        | 80      | 95     | 70     |
| 21, . . .         | 2,169,800                                        | 8,200                                           | 100                                        | 140     | 102    | 100    |
| 22, . . .         | 2,051,000                                        | 8,200                                           | 80                                         | 97      | 92     | 90     |
| 23, . . .         | 1,981,000                                        | 18,300                                          | 63                                         | 52      | 89     | 90     |
| 24, . . .         | 2,037,000                                        | 10,100                                          | 50                                         | 55      | 35     | 20     |
| 25, . . .         | 2,030,000                                        | 11,500                                          | 45                                         | 46      | 44     | 26     |
| 26, . . .         | 2,080,000                                        | -                                               | -                                          | -       | -      | -      |
| 27, . . .         | 1,985,200                                        | 10,500                                          | 26                                         | 70      | 82     | 54     |
| 28, . . .         | 2,046,800                                        | 9,100                                           | 76                                         | 90      | 112    | 130    |
| 29, . . .         | 2,023,000                                        | 12,300                                          | 78                                         | 80      | 45     | 88     |
| 30, . . .         | 1,916,000                                        | 6,800                                           | 75                                         | -       | -      | -      |

Quantity of effluent for month was 56,953,600 gallons per acre.

The outlet pipe was closed November 11, 9 to 10 A.M., but no air came out at the surface. The surface was scraped November 13 between 11 A.M. and 3 P.M.



*Filter No. 3 B (Intermittent) — Continued.*

| DATE—1893.        | Quantity<br>of Effluent.<br>Gallons per<br>Acre Daily. | Bacteria per<br>Cubic<br>Centimeter<br>in Applied<br>Water. | BACTERIA PER CUBIC CENTIMETER IN EFFLUENT. |         |        |        |
|-------------------|--------------------------------------------------------|-------------------------------------------------------------|--------------------------------------------|---------|--------|--------|
|                   |                                                        |                                                             | 8 A.M.                                     | 11 A.M. | 2 P.M. | 4 P.M. |
| December 1, . . . | 2,064,900                                              | 12,300                                                      | 409                                        | 270     | 190    | 167    |
| 2, . . .          | 2,055,000                                              | 15,500                                                      | 790                                        | 390     | 240    | 250    |
| 3, . . .          | 0                                                      | -                                                           | -                                          | -       | -      | -      |
| 4, . . .          | 1,897,800                                              | 11,200                                                      | 558                                        | 336     | 300    | 240    |
| 5, . . .          | 1,920,800                                              | 11,700                                                      | 318                                        | 690     | 270    | 218    |
| 6, . . .          | 2,043,800                                              | 10,500                                                      | 288                                        | 360     | 170    | 165    |
| 7, . . .          | 1,986,200                                              | 11,900                                                      | 230                                        | 190     | 222    | 185    |
| 8, . . .          | 2,157,800                                              | 10,300                                                      | 192                                        | 249     | 218    | 294    |
| 9, . . .          | 2,190,600                                              | 10,400                                                      | 252                                        | 294     | -      | -      |
| 10, . . .         | 0                                                      | -                                                           | -                                          | -       | -      | -      |
| 11, . . .         | 2,207,800                                              | 9,200                                                       | 360                                        | 384     | 330    | 318    |
| 12, . . .         | 2,123,000                                              | 8,500                                                       | 275                                        | 270     | 202    | 252    |
| 13, . . .         | 2,025,600                                              | 7,400                                                       | 370                                        | 240     | 354    | 270    |
| 14, . . .         | 2,066,600                                              | 9,000                                                       | 130                                        | 192     | 336    | 318    |
| 15, . . .         | 2,100,700                                              | 7,200                                                       | 151                                        | 180     | 348    | 204    |
| 16, . . .         | 2,030,600                                              | 10,600                                                      | 270                                        | 150     | -      | -      |
| 17, . . .         | 0                                                      | -                                                           | -                                          | -       | -      | -      |
| 18, . . .         | 2,254,800                                              | 12,800                                                      | 270                                        | 258     | 240    | 720    |
| 19, . . .         | 1,900,200                                              | 21,200                                                      | 300                                        | 195     | 240    | 270    |
| 20, . . .         | 1,938,400                                              | 11,600                                                      | 288                                        | 310     | 330    | 420    |
| 21, . . .         | 2,084,600                                              | 11,200                                                      | 180                                        | 193     | 180    | 240    |
| 22, . . .         | 2,103,000                                              | 9,100                                                       | 329                                        | 220     | 276    | 288    |
| 23, . . .         | 2,057,000                                              | 8,300                                                       | 386                                        | 294     | 228    | 170    |
| 24, . . .         | 1,817,600                                              | -                                                           | -                                          | -       | -      | -      |
| 25, . . .         | 0                                                      | -                                                           | -                                          | -       | -      | -      |
| 26, . . .         | 2,017,400                                              | 10,300                                                      | 360                                        | 360     | 246    | 210    |
| 27, . . .         | 2,053,800                                              | 5,000                                                       | 220                                        | 147     | 167    | 140    |
| 28, . . .         | 2,052,000                                              | 5,300                                                       | 285                                        | 261     | 120    | 156    |
| 29, . . .         | 2,015,600                                              | 5,800                                                       | 340                                        | 339     | 128    | 146    |
| 30, . . .         | 2,069,900                                              | 7,600                                                       | 153                                        | 227     | 133    | 140    |
| 31, . . .         | 0                                                      | -                                                           | -                                          | -       | -      | -      |

Quantity of effluent for month was 53,275,300 gallons per acre.

To remove the air held in the pores of the sand and which prevented a normal flow of water the outlet was closed December 19, 9.25 to 10.25 A.M., and December 24, 9.45 to 11 A.M.

*Filter No. 8 A (Continuous) — Continued.*

| DATE — 1893.      | Quantity<br>of Effluent.<br>—<br>Gallons per<br>Acre Daily. | Bacteria per<br>Cubic<br>Centimeter<br>in Applied<br>Water. | BACTERIA PER CUBIC CENTIMETER IN EFFLUENT. |         |        |        |
|-------------------|-------------------------------------------------------------|-------------------------------------------------------------|--------------------------------------------|---------|--------|--------|
|                   |                                                             |                                                             | 8 A.M.                                     | 11 A.M. | 2 P.M. | 4 P.M. |
| December 1, . . . | 1,764,200                                                   | 12,300                                                      | 57                                         | 170     | 210    | 147    |
| 2, . . .          | 1,837,500                                                   | 15,500                                                      | 354                                        | —       | —      | 843    |
| 3, . . .          | 1,837,500                                                   | —                                                           | —                                          | —       | —      | —      |
| 4, . . .          | 1,953,600                                                   | 11,200                                                      | 180                                        | 170     | 300    | 120    |
| 5, . . .          | 2,037,000                                                   | 11,700                                                      | 215                                        | 184     | 246    | 140    |
| 6, . . .          | 2,009,000                                                   | 10,500                                                      | 110                                        | 140     | 180    | 120    |
| 7, . . .          | 1,957,600                                                   | 11,900                                                      | 123                                        | 105     | 82     | 77     |
| 8, . . .          | 2,009,000                                                   | 10,300                                                      | 72                                         | 86      | 125    | 146    |
| 9, . . .          | 1,980,500                                                   | 10,400                                                      | 35                                         | 79      | —      | —      |
| 10, . . .         | 1,980,500                                                   | —                                                           | —                                          | —       | —      | —      |
| 11, . . .         | 2,016,000                                                   | 9,200                                                       | 45                                         | 67      | 70     | 98     |
| 12, . . .         | 2,016,000                                                   | 8,500                                                       | 49                                         | 63      | 60     | 57     |
| 13, . . .         | 2,030,000                                                   | 7,400                                                       | 44                                         | 32      | 43     | 48     |
| 14, . . .         | 2,090,000                                                   | 9,000                                                       | 51                                         | 73      | 68     | 81     |
| 15, . . .         | 1,920,200                                                   | 7,200                                                       | 34                                         | 26      | 30     | 74     |
| 16, . . .         | 2,132,500                                                   | 10,600                                                      | 22                                         | 46      | —      | —      |
| 17, . . .         | 2,132,500                                                   | —                                                           | —                                          | —       | —      | —      |
| 18, . . .         | 2,030,000                                                   | 12,800                                                      | 110                                        | 138     | 120    | 147    |
| 19, . . .         | 1,988,000                                                   | 21,200                                                      | 98                                         | 75      | 140    | 110    |
| 20, . . .         | 2,037,000                                                   | 11,600                                                      | 114                                        | 98      | 72     | 120    |
| 21, . . .         | 2,016,000                                                   | 11,200                                                      | 41                                         | 53      | 56     | 59     |
| 22, . . .         | 1,988,000                                                   | 9,100                                                       | 79                                         | 52      | 96     | 80     |
| 23, . . .         | 2,058,000                                                   | 8,300                                                       | 99                                         | 92      | 97     | —      |
| 24, . . .         | 1,885,700                                                   | —                                                           | —                                          | —       | —      | —      |
| 25, . . .         | 1,885,700                                                   | —                                                           | —                                          | —       | —      | —      |
| 26, . . .         | 1,994,000                                                   | 10,300                                                      | 44                                         | 49      | 49     | 50     |
| 27, . . .         | 1,829,800                                                   | 5,000                                                       | 35                                         | 45      | 50     | 56     |
| 28, . . .         | 1,796,000                                                   | 5,300                                                       | 50                                         | 87      | 79     | 143    |
| 29, . . .         | 1,715,000                                                   | 5,800                                                       | 165                                        | 210     | 302    | 306    |
| 30, . . .         | 2,016,000                                                   | 7,600                                                       | 74                                         | 78      | 92     | 93     |
| 31, . . .         | 2,016,000                                                   | —                                                           | —                                          | —       | —      | —      |

Quantity of effluent for month was 60,958,800 gallons per acre.

The surface was scraped on December 2 between 10 A.M. and 4 P.M. The loss of head was equal to the depth of the filter on December 29; the ice 3 to 8 inches in thickness was removed and the outlet closed 8.30 to 11.45 A.M. to allow the escape of air held in the sand.

*Filter No. 3 B (Intermittent) — Continued.*

| DATE—1894.       | Quantity of Effluent.<br>Gallons per Acre Daily. | LOSS OF HEAD.<br>(INCHES.) |        | Bacteria per Cubic Centimeter in Applied Water. | BACTERIA PER CUBIC CENTIMETER IN EFFLUENT. |         |        |        |
|------------------|--------------------------------------------------|----------------------------|--------|-------------------------------------------------|--------------------------------------------|---------|--------|--------|
|                  |                                                  | 8 A.M.                     | 4 P.M. |                                                 | 8 A.M.                                     | 11 A.M. | 2 P.M. | 4 P.M. |
| January 1, . . . | 2,165,000                                        | -                          | -      | 4,500                                           | 338                                        | 204     | 252    | 286    |
| 2, . . .         | 1,955,600                                        | -                          | -      | 5,000                                           | 258                                        | 166     | 170    | 185    |
| 3, . . .         | 1,593,400                                        | -                          | -      | 3,600                                           | 152                                        | 150     | 142    | 108    |
| 4, . . .         | 1,862,200                                        | -                          | -      | 4,400                                           | 112                                        | 211     | 223    | 210    |
| 5, . . .         | 1,914,800                                        | -                          | -      | 6,000                                           | 150                                        | 160     | 146    | 155    |
| 6, . . .         | 2,090,600                                        | -                          | -      | 7,800                                           | 305                                        | 273     | 173    | 112    |
| 7, . . .         | 0                                                | -                          | -      | -                                               | -                                          | -       | -      | -      |
| 8, . . .         | 2,068,600                                        | 53.3                       | 13.3   | 8,200                                           | 235                                        | 205     | 378    | 522    |
| 9, . . .         | 2,058,600                                        | 43.0                       | 17.8   | 7,500                                           | 283                                        | 224     | 310    | 148    |
| 10, . . .        | 2,222,200                                        | 40.0                       | 14.0   | 6,700                                           | 353                                        | 277     | 280    | 267    |
| 11, . . .        | 2,087,800                                        | 14.0                       | 15.0   | 6,800                                           | 276                                        | 210     | 170    | 140    |
| 12, . . .        | 1,988,800                                        | 14.8                       | 15.5   | 7,600                                           | 239                                        | 195     | 197    | 191    |
| 13, . . .        | 340,000                                          | 61.0                       | -      | 7,900                                           | -                                          | -       | -      | 119    |
| 14, . . .        | 0                                                | -                          | -      | -                                               | -                                          | -       | -      | -      |
| 15, . . .        | 1,253,400                                        | -                          | 58.0   | 10,500                                          | -                                          | -       | -      | 149    |
| 16, . . .        | 1,815,600                                        | 72.0                       | 65.0   | 7,100                                           | -                                          | 468     | 334    | 348    |
| 17, . . .        | 1,696,200                                        | 62.5                       | 57.8   | 6,800                                           | -                                          | 215     | 348    | 474    |
| 18, . . .        | 2,037,000                                        | 57.5                       | 51.5   | 8,100                                           | 202                                        | 210     | 372    | 149    |
| 19, . . .        | 2,022,400                                        | 16.5                       | 15.0   | 8,500                                           | 206                                        | 220     | 196    | 189    |
| 20, . . .        | 1,995,000                                        | 43.5                       | 14.3   | 7,300                                           | 118                                        | 221     | 330    | 285    |
| 21, . . .        | 0                                                | -                          | -      | -                                               | -                                          | -       | -      | -      |
| 22, . . .        | 2,133,800                                        | 16.5                       | 14.3   | 9,700                                           | 226                                        | 314     | 156    | 159    |
| 23, . . .        | 1,950,200                                        | 13.5                       | 15.3   | 8,600                                           | 316                                        | 269     | 210    | 241    |
| 24, . . .        | 1,970,600                                        | 15.3                       | 16.0   | 6,200                                           | 124                                        | 242     | 191    | 110    |
| 25, . . .        | 1,957,600                                        | 15.3                       | 16.0   | 6,300                                           | 80                                         | 165     | 136    | 95     |
| 26, . . .        | 2,168,000                                        | 41.0                       | 18.0   | 6,100                                           | 96                                         | 145     | 159    | 241    |
| 27, . . .        | 2,145,800                                        | 13.0                       | 13.5   | 9,000                                           | 92                                         | 117     | 162    | 122    |
| 28, . . .        | 0                                                | -                          | -      | -                                               | -                                          | -       | -      | -      |
| 29, . . .        | 1,874,800                                        | 14.5                       | 15.0   | 6,400                                           | 115                                        | 191     | 201    | 167    |
| 30, . . .        | 0                                                | -                          | -      | 6,000                                           | -                                          | -       | -      | -      |
| 31, . . .        | 2,040,000                                        | -                          | 12.3   | 7,700                                           | -                                          | -       | -      | 170    |

Quantity of effluent for month was 49,358,000 gallons per acre.

January 4, 2 to 8 inches of ice removed. January 13, outlet closed 10.45 A.M. to 2.50 P.M. January 15, ice 6 inches thick was broken along the edge and outlet closed until 3.50 P.M. January 16, 4 inches of ice removed and outlet closed 10 to 11.15 A.M. January 17, outlet opened at 10.30 A.M.; a large quantity of air appeared at the surface. January 31, a wooden distributing trough put on surface.

*Filter No. 8 A (Continuous) — Continued.*

| DATE — 1894.     | Quantity of<br>Effluent.<br>Gallons per<br>Acre Daily. | LOSS OF HEAD.<br>(INCHES.) |        | Bacteria per<br>Cubic<br>Centimeter<br>in Applied<br>Water. | BACTERIA PER CUBIC CENTIMETER<br>IN EFFLUENT. |         |        |        |
|------------------|--------------------------------------------------------|----------------------------|--------|-------------------------------------------------------------|-----------------------------------------------|---------|--------|--------|
|                  |                                                        | 8 A.M.                     | 4 P.M. |                                                             | 8 A.M.                                        | 11 A.M. | 2 P.M. | 4 P.M. |
| January 1, . . . | 2,016,000                                              | -                          | -      | 4,500                                                       | 44                                            | 39      | 40     | 50     |
| 2, . . .         | 2,016,000                                              | -                          | -      | 5,000                                                       | 49                                            | 47      | 52     | 59     |
| 3, . . .         | 2,072,000                                              | -                          | -      | 3,600                                                       | 59                                            | 65      | 58     | 51     |
| 4, . . .         | 1,974,000                                              | -                          | -      | 4,400                                                       | 37                                            | 48      | 54     | 40     |
| 5, . . .         | 2,016,000                                              | -                          | -      | 6,000                                                       | 24                                            | 31      | 58     | 60     |
| 6, . . .         | 2,016,000                                              | -                          | -      | 7,800                                                       | 24                                            | 30      | 47     | 58     |
| 7, . . .         | 2,016,000                                              | -                          | -      | -                                                           | -                                             | -       | -      | -      |
| 8, . . .         | 1,945,000                                              | 13.5                       | 21.0   | 8,200                                                       | 47                                            | 42      | 50     | 52     |
| 9, . . .         | 2,245,400                                              | 16.5                       | 24.5   | 7,500                                                       | 36                                            | 48      | 56     | 33     |
| 10, . . .        | 1,892,400                                              | 24.5                       | 23.5   | 6,700                                                       | 71                                            | 126     | 98     | 146    |
| 11, . . .        | 1,895,000                                              | 31.0                       | 31.0   | 6,800                                                       | 102                                           | 110     | 118    | 122    |
| 12, . . .        | 2,039,000                                              | 48.8                       | 51.5   | 7,600                                                       | 148                                           | 165     | 135    | 184    |
| 13, . . .        | 1,925,000                                              | 62.0                       | 60.3   | 7,900                                                       | 221                                           | 288     | 243    | 206    |
| 14, . . .        | 1,925,000                                              | -                          | -      | -                                                           | -                                             | -       | -      | -      |
| 15, . . .        | 1,623,000                                              | 69.0                       | 73.0   | 10,500                                                      | 200                                           | 252     | 240    | 208    |
| 16, . . .        | 1,533,000                                              | 73.0                       | 12.5   | 7,100                                                       | 105                                           | -       | 153    | 153    |
| 17, . . .        | 2,062,000                                              | 11.5                       | 11.8   | 6,800                                                       | 139                                           | 98      | 105    | 125    |
| 18, . . .        | 2,037,000                                              | 12.0                       | 12.0   | 8,100                                                       | 89                                            | 77      | 73     | 92     |
| 19, . . .        | 2,023,000                                              | 13.0                       | 12.8   | 8,500                                                       | 38                                            | 86      | 52     | 75     |
| 20, . . .        | 2,019,500                                              | 14.5                       | 15.0   | 7,300                                                       | 45                                            | 57      | 43     | 37     |
| 21, . . .        | 2,019,500                                              | -                          | -      | -                                                           | -                                             | -       | -      | -      |
| 22, . . .        | 1,886,200                                              | 19.0                       | 20.5   | 9,700                                                       | 23                                            | 25      | 32     | 76     |
| 23, . . .        | 2,030,000                                              | 23.5                       | 24.5   | 8,600                                                       | 45                                            | 48      | 51     | 81     |
| 24, . . .        | 1,865,800                                              | 27.3                       | 32.3   | 6,200                                                       | 83                                            | 61      | 44     | 41     |
| 25, . . .        | 1,704,600                                              | 47.0                       | 57.5   | 6,300                                                       | 42                                            | 27      | 65     | 68     |
| 26, . . .        | 219,000                                                | 73.0                       | 47.0   | 6,100                                                       | 60                                            | 53      | 69     | -      |
| 27, . . .        | 1,841,200                                              | 37.0                       | 62.0   | 9,000                                                       | 49                                            | 58      | 51     | 111    |
| 28, . . .        | 400,000                                                | -                          | -      | -                                                           | -                                             | -       | -      | -      |
| 29, . . .        | 1,607,000                                              | 73.0                       | 10.5   | 6,400                                                       | 23                                            | -       | -      | 64     |
| 30, . . .        | 2,044,000                                              | 13.5                       | 13.5   | 6,900                                                       | 30                                            | 53      | 56     | 58     |
| 31, . . .        | 1,988,000                                              | 10.3                       | 10.3   | 7,700                                                       | 46                                            | 41      | 46     | 46     |

Quantity of effluent for month, 56,835,600 gallons per acre.

January 16, 2 to 8.5 inches ice removed, and outlet closed 8 A.M. to 1.50 P.M. to allow escape of air. January 26, outlet closed 9.10 to 11.10 A.M., and from 2 P.M. to 8.35 A.M. January 27. January 29, 6 inches ice removed and outlet closed 9 A.M. to 3.20 P.M.

*Filter No. 3 B (Intermittent) — Continued.*

| DATE—1894.        | Quantity of Effluent.<br>Gallons per Acre Daily. | LOSS OF HEAD.<br>(INCHES.) |        | Bacteria per Cubic Centimeter in Applied Water. | BACTERIA PER CUBIC CENTIMETER IN EFFLUENT. |         |        |        |
|-------------------|--------------------------------------------------|----------------------------|--------|-------------------------------------------------|--------------------------------------------|---------|--------|--------|
|                   |                                                  | 8 A.M.                     | 4 P.M. |                                                 | 8 A.M.                                     | 11 A.M. | 2 P.M. | 4 P.M. |
| February 1, . . . | 2,152,400                                        | 12.0                       | 11.5   | 7,900                                           | 151                                        | 146     | 114    | 105    |
| 2, . . .          | 2,021,800                                        | 15.5                       | 14.0   | 7,300                                           | 255                                        | 278     | 131    | 114    |
| 3, . . .          | 2,019,000                                        | 14.0                       | 14.0   | 4,100                                           | 204                                        | 340     | 102    | 185    |
| 4, . . .          | 0                                                | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 5, . . .          | 1,881,600                                        | 11.3                       | 13.0   | 9,900                                           | 288                                        | 270     | 203    | 184    |
| 6, . . .          | 1,718,400                                        | 15.5                       | 13.8   | 8,900                                           | —                                          | 258     | 190    | 170    |
| 7, . . .          | 1,935,600                                        | 15.0                       | 15.3   | 10,700                                          | 208                                        | 190     | 121    | 135    |
| 8, . . .          | 2,098,600                                        | 15.0                       | 14.8   | 7,800                                           | 323                                        | 198     | 123    | —      |
| 9, . . .          | 2,056,600                                        | 13.5                       | 16.0   | 6,500                                           | 247                                        | 246     | 190    | 107    |
| 10, . . .         | 2,166,600                                        | 14.0                       | 15.0   | 9,300                                           | 306                                        | 280     | 116    | 128    |
| 11, . . .         | 0                                                | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 12, . . .         | 1,986,200                                        | 35.3                       | 15.8   | 12,400                                          | 255                                        | 178     | 216    | 437    |
| 13, . . .         | 1,830,800                                        | 10.0                       | 31.8   | 6,000                                           | —                                          | 225     | 170    | 226    |
| 14, . . .         | 1,729,400                                        | 14.5                       | 14.0   | 6,100                                           | 332                                        | 258     | 149    | 197    |
| 15, . . .         | 1,747,400                                        | 13.0                       | 14.5   | 7,500                                           | 271                                        | 218     | 125    | 138    |
| 16, . . .         | 1,314,200                                        | 14.5                       | 8.3    | 9,100                                           | 265                                        | 219     | 165    | 182    |
| 17, . . .         | 1,503,000                                        | 11.0                       | 8.3    | 7,300                                           | 212                                        | 127     | 135    | 120    |
| 18, . . .         | 0                                                | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 19, . . .         | 2,086,400                                        | 15.8                       | 16.0   | 10,100                                          | 205                                        | 180     | 158    | 140    |
| 20, . . .         | 1,504,000                                        | 15.0                       | 16.0   | 8,400                                           | 240                                        | 218     | 108    | 132    |
| 21, . . .         | 1,646,200                                        | 15.0                       | 15.8   | 8,700                                           | —                                          | 257     | 192    | 120    |
| 22, . . .         | 1,962,000                                        | 19.8                       | 17.3   | 8,600                                           | 153                                        | 160     | 155    | 189    |
| 23, . . .         | 1,734,600                                        | 13.3                       | 15.3   | 6,800                                           | 227                                        | 222     | 145    | —      |
| 24, . . .         | 10,000                                           | —                          | —      | 6,700                                           | —                                          | —       | —      | 372    |
| 25, . . .         | 458,800                                          | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 26, . . .         | 0                                                | —                          | —      | 9,500                                           | —                                          | —       | —      | —      |
| 27, . . .         | 1,544,400                                        | 10.0                       | 9.3    | 8,300                                           | 100                                        | 60      | 55     | 59     |
| 28, . . .         | 1,623,400                                        | 12.0                       | 12.3   | 6,400                                           | 120                                        | 180     | 120    | 160    |

Quantity of effluent for month was 40,731,400 gallons per acre.

February 1, the filter was not drained on the night preceding. February 24, the filter was filled from below with city filtered water. February 26, 6 inches of ice removed; 1 to 2.5 inches of frost in sand; filled with city-filtered water from below (rate, 1,150,000 gallons per acre daily) and allowed to stand over night. February 27, rate reduced from 10 to 8 gallons per minute.

*Filter No. 8 A (Continuous)* — Continued.

| DATE—1894.        | Quantity of Effluent.<br>Gallons per Acre Daily. | Loss of Head.<br>(INCHES.) |        | Bacteria per Cubic Centimeter in Applied Water. | BACTERIA PER CUBIC CENTIMETER IN EFFLUENT. |         |        |        |
|-------------------|--------------------------------------------------|----------------------------|--------|-------------------------------------------------|--------------------------------------------|---------|--------|--------|
|                   |                                                  | 8 A.M.                     | 4 P.M. |                                                 | 8 A.M.                                     | 11 A.M. | 2 P.M. | 4 P.M. |
| February 1, . . . | 2,016,000                                        | 9.0                        | 9.5    | 7,900                                           | 42                                         | 28      | 32     | 62     |
| 2, . . .          | 2,016,000                                        | 10.5                       | 12.0   | 7,300                                           | 45                                         | 45      | 37     | 66     |
| 3, . . .          | 2,016,000                                        | 14.0                       | 15.0   | 4,100                                           | 52                                         | 69      | 40     | 59     |
| 4, . . .          | 2,016,000                                        | -                          | -      | -                                               | -                                          | -       | -      | -      |
| 5, . . .          | 2,009,000                                        | 21.0                       | 22.8   | 9,900                                           | 71                                         | 69      | 60     | 67     |
| 6, . . .          | 1,722,000                                        | 11.5                       | 17.8   | 8,900                                           | 58                                         | 50      | 40     | 38     |
| 7, . . .          | 2,016,000                                        | 20.8                       | 24.0   | 10,700                                          | 48                                         | 60      | 46     | 60     |
| 8, . . .          | 2,016,000                                        | 27.8                       | 33.5   | 7,800                                           | 81                                         | 39      | 39     | 34     |
| 9, . . .          | 1,704,400                                        | 48.3                       | 59.0   | 9,500                                           | 23                                         | 24      | 27     | 24     |
| 10, . . .         | 1,328,200                                        | 73.0                       | 40.0   | 9,300                                           | 102                                        | -       | -      | 29     |
| 11, . . .         | 1,328,200                                        | -                          | -      | -                                               | -                                          | -       | -      | -      |
| 12, . . .         | 1,519,000                                        | 78.0                       | 13.0   | 12,400                                          | 228                                        | -       | 152    | 119    |
| 13, . . .         | 2,058,000                                        | 12.5                       | 13.0   | 6,000                                           | 110                                        | 104     | 91     | 115    |
| 14, . . .         | 2,009,000                                        | 13.0                       | 13.5   | 6,100                                           | 92                                         | 103     | 106    | 76     |
| 15, . . .         | 1,723,000                                        | 14.8                       | 16.0   | 7,500                                           | 83                                         | 66      | 86     | 119    |
| 16, . . .         | 1,945,400                                        | 22.0                       | 25.0   | 9,100                                           | 61                                         | 80      | 104    | 108    |
| 17, . . .         | 1,000,000                                        | 31.5                       | 37.0   | 7,300                                           | 95                                         | 94      | 114    | 116    |
| 18, . . .         | 290,000                                          | -                          | -      | -                                               | -                                          | -       | -      | -      |
| 19, . . .         | 0                                                | 73.0                       | -      | 10,100                                          | 98                                         | -       | -      | -      |
| 20, . . .         | 1,843,000                                        | 19.0                       | 36.0   | 8,400                                           | 49                                         | 80      | 95     | 99     |
| 21, . . .         | 151,200                                          | 61.0                       | -      | 8,700                                           | 221                                        | -       | -      | -      |
| 22, . . .         | 2,009,000                                        | 11.3                       | 10.3   | 8,600                                           | 136                                        | 167     | 117    | 88     |
| 23, . . .         | 2,016,000                                        | 11.0                       | 11.0   | 6,300                                           | 91                                         | 97      | 75     | 60     |
| 24, . . .         | 763,000                                          | 8.5                        | 9.0    | 6,700                                           | 98                                         | 98      | 94     | 97     |
| 25, . . .         | 458,800                                          | -                          | -      | -                                               | -                                          | -       | -      | -      |
| 26, . . .         | 0                                                | -                          | -      | 9,500                                           | -                                          | -       | -      | -      |
| 27, . . .         | 1,347,000                                        | 10.0                       | 6.0    | 8,300                                           | 37                                         | 58      | 114    | 38     |
| 28, . . .         | 1,440,000                                        | 6.5                        | 6.5    | 6,400                                           | 48                                         | 45      | 60     | 51     |

Quantity of effluent for month was 40,765,200 gallons per acre.

February 6, inlet pipe frozen and surface uncovered. February 10, ice 4 inches thick broken along the sides and outlet closed 7.55 A.M. to 3.45 P.M. February 12, ice 3 to 6.5 inches thick removed and outlet closed 8 A.M. to 1.40 P.M. February 19, ice 4 inches thick broken along the sides and outlet closed 8.30 A.M. to February 20, 8 A.M. February 21, 2 to 6 inches ice removed and surface scraped. After filling, filter was allowed to stand with outlet closed from 9 P.M. till 8 A.M. the next morning. February 24, inlet pipe frozen and surface uncovered. February 15, filter allowed to drain. February 26, filled with city filtered water from below and allowed to stand over night with outlet closed. February 27, rate reduced from 7 to 5 gallons per minute.

*Filter No. 3 B (Intermittent) — Continued.*

| DATE — 1894.   | Quantity of Effluent.<br>Gallons per Acre Daily. | LOSS OF HEAD.<br>(INCHES.) |        | Bacteria per Cubic Centimeter in Applied Water. | BACTERIA PER CUBIC CENTIMETER IN EFFLUENT. |         |        |        |
|----------------|--------------------------------------------------|----------------------------|--------|-------------------------------------------------|--------------------------------------------|---------|--------|--------|
|                |                                                  | 8 A.M.                     | 4 P.M. |                                                 | 8 A.M.                                     | 11 A.M. | 2 P.M. | 4 P.M. |
| March 1, . . . | 1,823,200                                        | 11.5                       | 13.0   | 7,300                                           | 135                                        | 174     | 128    | 130    |
| 2, . . .       | 1,786,200                                        | 12.5                       | 12.5   | 9,800                                           | 114                                        | 191     | 178    | 116    |
| 3, . . .       | 1,798,600                                        | 10.0                       | 11.8   | 6,900                                           | 239                                        | 119     | 91     | 153    |
| 4, . . .       | 0                                                | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 5, . . .       | 2,273,000                                        | 13.5                       | 12.5   | 7,000                                           | 84                                         | 52      | 82     | 51     |
| 6, . . .       | 1,787,600                                        | 13.3                       | 12.0   | 11,800                                          | 107                                        | 101     | 87     | 77     |
| 7, . . .       | 1,747,400                                        | 9.5                        | 11.8   | 13,600                                          | 360                                        | 190     | 115    | 159    |
| 8, . . .       | 1,806,600                                        | 12.5                       | 12.5   | 18,400                                          | 256                                        | 232     | 152    | 190    |
| 9, . . .       | 1,798,600                                        | 12.0                       | 14.0   | 13,000                                          | 281                                        | 340     | 245    | 141    |
| 10, . . .      | 1,569,200                                        | 12.0                       | 13.8   | 12,800                                          | 337                                        | 290     | 156    | 159    |
| 11, . . .      | 0                                                | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 12, . . .      | 1,933,000                                        | 13.5                       | 14.3   | 10,900                                          | 80                                         | 56      | 84     | 132    |
| 13, . . .      | 1,809,800                                        | 13.0                       | 13.5   | 9,800                                           | 285                                        | 221     | 217    | 102    |
| 14, . . .      | 1,827,400                                        | 10.5                       | 13.8   | 8,600                                           | 257                                        | 196     | 136    | 61     |
| 15, . . .      | 1,726,600                                        | 11.0                       | 14.0   | 7,800                                           | 220                                        | 190     | 183    | 130    |
| 16, . . .      | 1,836,000                                        | 10.5                       | 13.3   | 6,300                                           | 167                                        | 161     | 117    | 96     |
| 17, . . .      | 400,000                                          | 18.5                       | —      | 6,000                                           | 150                                        | —       | —      | —      |
| 18, . . .      | 0                                                | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 19, . . .      | 1,736,200                                        | 10.0                       | 9.0    | 5,200                                           | 29                                         | 41      | 63     | 80     |
| 20, . . .      | 1,704,000                                        | 10.5                       | 10.3   | 4,100                                           | 144                                        | 190     | 114    | 80     |
| 21, . . .      | 1,656,400                                        | 9.5                        | 11.5   | 3,900                                           | 130                                        | 136     | 80     | 112    |
| 22, . . .      | 1,779,200                                        | 11.0                       | 11.5   | 4,000                                           | —                                          | 107     | 87     | 76     |
| 23, . . .      | 1,598,400                                        | 9.5                        | 13.5   | 4,900                                           | 140                                        | 110     | 42     | 108    |
| 24, . . .      | 1,625,600                                        | 10.8                       | 11.5   | 3,600                                           | 160                                        | 153     | 90     | 50     |
| 25, . . .      | 0                                                | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 26, . . .      | 1,767,200                                        | 11.5                       | 12.0   | 4,900                                           | 78                                         | 81      | 89     | 95     |
| 27, . . .      | 1,376,000                                        | —                          | —      | 3,500                                           | 230                                        | 196     | 98     | 122    |
| 28, . . .      | 1,888,000                                        | 10.8                       | 11.8   | 2,100                                           | 206                                        | 155     | 95     | 75     |
| 29, . . .      | 1,649,600                                        | 13.0                       | 14.0   | 3,600                                           | 157                                        | 114     | 75     | 56     |
| 30, . . .      | 1,617,600                                        | 12.3                       | 12.8   | 8,600                                           | 308                                        | 152     | 126    | 175    |
| 31, . . .      | 1,640,000                                        | 11.0                       | 11.5   | 10,200                                          | 290                                        | 242     | 210    | 142    |

Quantity of effluent for month was 45,960,400 gallons per acre.

March 4 and 11, filter filled with city filtered water from below and allowed to stand over night. March 17, surface scraped and new sand added to ridge the surface similar to that of the Lawrence city filter; the sand at the sides at right angles to the wooden conduit was made 6 inches deeper than in the middle, towards which it was graded. The filter was filled from below with city filtered water on the night of March 18. The filter was filled as usual, from the top, on March 25, and allowed to stand over night with the outlet closed.

*Filter No. 8 A (Continuous) — Continued.*

| DATE—1894.     | Quantity of Effluent.<br>Gallons per Acre Daily. | LOSS OF HEAD.<br>(INCHES.) |        | Bacteria per Cubic Centimeter in Applied Water. | BACTERIA PER CUBIC CENTIMETER IN EFFLUENT. |         |        |        |
|----------------|--------------------------------------------------|----------------------------|--------|-------------------------------------------------|--------------------------------------------|---------|--------|--------|
|                |                                                  | 8 A.M.                     | 4 P.M. |                                                 | 8 A.M.                                     | 11 A.M. | 2 P.M. | 4 P.M. |
| March 1, . . . | 1,445,000                                        | 6.5                        | 6.5    | 7,300                                           | 28                                         | 58      | 40     | 42     |
| 2, . . .       | 1,440,000                                        | 6.5                        | 6.5    | 9,800                                           | 33                                         | 81      | 56     | 61     |
| 3, . . .       | 1,380,000                                        | 6.5                        | 6.5    | 6,900                                           | 51                                         | 42      | 56     | 58     |
| 4, . . .       | 500,000                                          | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 5, . . .       | 1,270,000                                        | 7.5                        | 7.3    | 7,000                                           | —                                          | 74      | 49     | 26     |
| 6, . . .       | 1,440,000                                        | 8.0                        | 7.3    | 11,800                                          | 55                                         | 85      | 74     | 70     |
| 7, . . .       | 1,445,000                                        | 7.3                        | 6.5    | 13,600                                          | 74                                         | 66      | 80     | 63     |
| 8, . . .       | 1,445,000                                        | 7.0                        | 7.0    | 18,400                                          | 73                                         | 75      | 70     | 78     |
| 9, . . .       | 1,425,000                                        | 7.0                        | 6.5    | 13,000                                          | 87                                         | 110     | 63     | 97     |
| 10, . . .      | 1,390,000                                        | 6.5                        | 6.5    | 12,800                                          | 98                                         | 87      | 64     | 95     |
| 11, . . .      | 664,600                                          | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 12, . . .      | 1,240,000                                        | 7.5                        | 7.8    | 10,900                                          | —                                          | 63      | 44     | 55     |
| 13, . . .      | 1,440,000                                        | 8.0                        | 7.5    | 9,800                                           | 97                                         | 86      | 91     | 62     |
| 14, . . .      | 1,440,000                                        | 7.8                        | 7.8    | 8,600                                           | 89                                         | 87      | 95     | 98     |
| 15, . . .      | 1,440,000                                        | 8.8                        | 8.5    | 7,800                                           | 73                                         | 77      | 79     | 78     |
| 16, . . .      | 1,440,000                                        | 8.5                        | 8.0    | 6,300                                           | 87                                         | 63      | 75     | 67     |
| 17, . . .      | 664,600                                          | 8.0                        | —      | 6,000                                           | 50                                         | —       | —      | —      |
| 18, . . .      | 0                                                | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 19, . . .      | 1,245,000                                        | 7.3                        | 7.0    | 5,200                                           | —                                          | 64      | 59     | 49     |
| 20, . . .      | 1,395,000                                        | 7.8                        | 7.8    | 4,100                                           | 102                                        | 96      | 106    | 93     |
| 21, . . .      | 1,440,000                                        | 7.5                        | 7.5    | 3,900                                           | 75                                         | 40      | 92     | 65     |
| 22, . . .      | 1,440,000                                        | 6.5                        | 6.5    | 4,000                                           | 70                                         | 78      | 56     | 74     |
| 23, . . .      | 1,440,000                                        | 6.5                        | 6.5    | 4,900                                           | 86                                         | 78      | 81     | 60     |
| 24, . . .      | 1,447,500                                        | 6.5                        | 6.5    | 3,600                                           | 55                                         | 63      | 61     | 61     |
| 25, . . .      | 1,447,500                                        | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 26, . . .      | 1,455,000                                        | 7.0                        | 6.8    | 4,900                                           | 50                                         | 46      | 49     | 41     |
| 27, . . .      | 1,410,000                                        | —                          | —      | 3,500                                           | 56                                         | 54      | 55     | 54     |
| 28, . . .      | 1,440,000                                        | 6.5                        | 6.5    | 2,100                                           | 24                                         | 26      | 19     | 20     |
| 29, . . .      | 1,440,000                                        | 6.5                        | 6.5    | 3,600                                           | 32                                         | 34      | 41     | 36     |
| 30, . . .      | 1,440,000                                        | 7.5                        | 8.5    | 8,600                                           | 78                                         | 88      | 93     | 90     |
| 31, . . .      | 1,440,000                                        | 8.0                        | 8.0    | 10,200                                          | 95                                         | 106     | 100    | 115    |

Quantity of effluent for month was 39,995,200 gallons per acre.

The filter was allowed to drain March 4, 11 and 17; and was filled with city filtered water from below March 5, 12 and 19, and put in operation in the usual manner as soon as the surface was covered. The surface was scraped on March 17.



*Filter No. 3 B (Intermittent) — Concluded.*

| DATE — 1894.   | Quantity of Effluent.<br>Gallons per Acre Daily. | LOSS OF HEAD.<br>(INCHES.) |        | Bacteria per Cubic Centimeter in Applied Water. | BACTERIA PER CUBIC CENTIMETER IN EFFLUENT. |         |        |        |
|----------------|--------------------------------------------------|----------------------------|--------|-------------------------------------------------|--------------------------------------------|---------|--------|--------|
|                |                                                  | 8 A.M.                     | 4 P.M. |                                                 | 8 A.M.                                     | 11 A.M. | 2 P.M. | 4 P.M. |
| April 1, . . . | 0                                                | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 2, . . .       | 1,771,200                                        | 11.0                       | 11.3   | 9,400                                           | 133                                        | 142     | 65     | 74     |
| 3, . . .       | 1,633,000                                        | 11.8                       | 11.8   | 5,600                                           | 225                                        | 338     | 172    | 118    |
| 4, . . .       | 1,506,600                                        | 11.5                       | 12.0   | 16,900                                          | 300                                        | 270     | 190    | 31     |
| 5, . . .       | 1,827,400                                        | 10.5                       | 12.3   | 13,600                                          | 128                                        | 143     | 37     | 76     |
| 6, . . .       | 1,708,800                                        | 12.0                       | 12.3   | 9,400                                           | 135                                        | 142     | 71     | 70     |
| 7, . . .       | 1,688,000                                        | 11.0                       | 11.8   | 12,800                                          | 245                                        | 206     | 95     | 104    |
| 8, . . .       | 0                                                | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 9, . . .       | 1,793,600                                        | 10.3                       | 11.8   | 14,700                                          | 112                                        | 107     | 90     | 84     |
| 10, . . .      | 1,643,200                                        | 11.8                       | 13.0   | 14,500                                          | 249                                        | 203     | 108    | 114    |
| 11, . . .      | 1,672,000                                        | 13.0                       | 13.8   | 13,800                                          | 159                                        | 150     | 112    | 103    |
| 12, . . .      | 1,684,800                                        | 11.0                       | 14.0   | 20,700                                          | 127                                        | 136     | 112    | 71     |
| 13, . . .      | 1,696,000                                        | 13.0                       | 14.3   | 20,600                                          | 95                                         | 173     | 92     | 70     |
| 14, . . .      | 1,657,600                                        | 10.3                       | 15.0   | 19,500                                          | 135                                        | 120     | 102    | 88     |
| 15, . . .      | 0                                                | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 16, . . .      | 1,763,000                                        | 9.8                        | 11.3   | 20,000                                          | 80                                         | 60      | 47     | 82     |
| 17, . . .      | 1,694,800                                        | 10.0                       | 11.8   | 8,300                                           | 110                                        | 75      | 65     | 38     |
| 18, . . .      | 1,697,600                                        | 11.0                       | 12.5   | 11,600                                          | 66                                         | 54      | 26     | 35     |
| 19, . . .      | 1,652,800                                        | 12.0                       | 12.8   | 12,000                                          | 108                                        | 101     | 83     | 72     |
| 20, . . .      | 1,700,200                                        | 11.0                       | 12.0   | 15,100                                          | 92                                         | 88      | 86     | 69     |
| 21, . . .      | 1,723,600                                        | 11.0                       | 12.5   | 28,200                                          | 114                                        | 76      | 82     | 97     |
| 22, . . .      | 0                                                | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 23, . . .      | 848,000                                          | 11.0                       | 11.8   | 9,800                                           | 235                                        | 140     | 66     | 97     |
| 24, . . .      | 1,795,200                                        | 10.5                       | 12.0   | 4,400                                           | 90                                         | 110     | 98     | 96     |
| 25, . . .      | 1,529,600                                        | 12.5                       | 14.0   | 14,000                                          | 174                                        | 160     | 103    | 68     |
| 26, . . .      | 832,000                                          | 15.8                       | 15.5   | 6,700                                           | 140                                        | 112     | 110    | 47     |
| 27, . . .      | 1,793,600                                        | 11.0                       | 12.0   | 5,500                                           | 160                                        | 82      | 70     | 40     |
| 28, . . .      | 1,763,000                                        | 12.3                       | 14.0   | 5,400                                           | 124                                        | 59      | 45     | 39     |
| 29, . . .      | 0                                                | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 30, . . .      | 1,758,800                                        | 10.3                       | 11.5   | 3,700                                           | 178                                        | 100     | 72     | 76     |

Quantity of effluent for month was 40,926,400 gallons per acre.

The filter was filled from the top in the usual way on April 1, 8, 15, 22 and 29, and allowed to stand over night with the outlet closed. The outlet was closed and the surface remained covered on the night of April 23.

*Filter No. 8 A (Continuous)*—Concluded.

| DATE—1894.       | Quantity of Effluent.<br>Gallons per Acre Daily. | LOSS OF HEAD.<br>(INCHES.) |        | Bacteria per Cubic Centimeter in Applied Water. | BACTERIA PER CUBIC CENTIMETER IN EFFLUENT. |         |        |        |
|------------------|--------------------------------------------------|----------------------------|--------|-------------------------------------------------|--------------------------------------------|---------|--------|--------|
|                  |                                                  | 8 A.M.                     | 4 P.M. |                                                 | 8 A.M.                                     | 11 A.M. | 2 P.M. | 4 P.M. |
| April 1, . . . . | 1,440,000                                        | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 2, . . . .       | 1,440,000                                        | 7.8                        | 9.0    | 9,400                                           | 79                                         | 92      | 58     | 96     |
| 3, . . . .       | 1,440,000                                        | 7.3                        | 8.0    | 5,600                                           | 54                                         | 42      | 83     | 58     |
| 4, . . . .       | 1,440,000                                        | 7.8                        | 8.5    | 16,900                                          | 40                                         | 58      | 53     | 74     |
| 5, . . . .       | 1,440,000                                        | 8.5                        | 9.5    | 13,800                                          | 46                                         | 43      | 46     | 41     |
| 6, . . . .       | 1,440,000                                        | 7.8                        | 8.3    | 9,400                                           | 41                                         | 46      | 38     | 44     |
| 7, . . . .       | 1,440,000                                        | 8.3                        | 9.0    | 12,800                                          | 38                                         | 39      | 48     | 54     |
| 8, . . . .       | 1,440,000                                        | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 9, . . . .       | 1,440,000                                        | 10.5                       | 11.3   | 14,700                                          | 38                                         | 35      | 41     | 38     |
| 10, . . . .      | 1,440,000                                        | 11.5                       | 11.5   | 14,500                                          | 38                                         | 50      | 33     | 40     |
| 11, . . . .      | 1,440,000                                        | 12.5                       | 13.0   | 13,800                                          | 38                                         | 31      | 27     | 26     |
| 12, . . . .      | 1,440,000                                        | 14.0                       | 14.0   | 20,700                                          | 17                                         | 24      | 30     | 24     |
| 13, . . . .      | 1,440,000                                        | 14.5                       | 14.8   | 20,600                                          | 39                                         | 32      | 24     | 30     |
| 14, . . . .      | 1,440,000                                        | 16.0                       | 14.3   | 19,500                                          | 37                                         | 40      | 45     | 25     |
| 15, . . . .      | 1,440,000                                        | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 16, . . . .      | 1,440,000                                        | 16.3                       | 16.5   | 20,000                                          | 39                                         | 30      | 49     | 40     |
| 17, . . . .      | 1,440,000                                        | 16.0                       | 17.0   | 8,300                                           | 35                                         | 28      | 28     | 30     |
| 18, . . . .      | 1,440,000                                        | 17.5                       | 19.5   | 11,600                                          | 18                                         | 21      | 18     | 24     |
| 19, . . . .      | 1,440,000                                        | 22.0                       | 27.3   | 12,000                                          | 30                                         | 32      | 28     | 28     |
| 20, . . . .      | 1,343,200                                        | 34.3                       | 41.0   | 15,100                                          | 23                                         | 29      | 29     | 31     |
| 21, . . . .      | 1,579,100                                        | 49.0                       | 59.0   | 28,200                                          | 27                                         | 21      | 28     | 28     |
| 22, . . . .      | 500,000                                          | —                          | —      | —                                               | —                                          | —       | —      | 29     |
| 23, . . . .      | 279,200                                          | —                          | —      | 9,800                                           | 26                                         | —       | —      | —      |
| 24, . . . .      | 1,440,000                                        | 6.0                        | 5.0    | 4,400                                           | 51                                         | 62      | 52     | 40     |
| 25, . . . .      | 1,440,000                                        | 5.0                        | 5.0    | 14,000                                          | 60                                         | 43      | 56     | 59     |
| 26, . . . .      | 1,440,000                                        | 5.0                        | 5.0    | 6,700                                           | 47                                         | 36      | 31     | 38     |
| 27, . . . .      | 1,440,000                                        | 5.0                        | 5.0    | 5,500                                           | 53                                         | 43      | 25     | 49     |
| 28, . . . .      | 1,440,000                                        | 5.0                        | 5.0    | 5,400                                           | 50                                         | 47      | 54     | 53     |
| 29, . . . .      | 1,440,000                                        | —                          | —      | —                                               | —                                          | —       | —      | —      |
| 30, . . . .      | 1,440,000                                        | 4.5                        | 4.5    | 3,700                                           | 41                                         | 42      | 57     | 61     |

Quantity of effluent for month was 41,141,500 gallons per acre.  
The surface was scraped on April 23.

## LAWRENCE CITY FILTER.

This filter was first put in use Sept. 20, 1893. The construction and operation of the filter are fully described in an article beyond by its designer, Mr. Hiram F. Mills, A.M., C.E., chairman of the committee on water supply and sewerage of the State Board of Health. Briefly, it is 2.5 acres in area; the underdrains conduct the effluent to a collecting conduit and thence to the pump well. The nominal capacity of the pumps is 5,000,000 gallons in 24 hours, and when pumping at this rate water passes through the filter at a rate of 2,000,000 gallons per acre in 24 hours. The average daily consumption is a little over 3,000,000 gallons, and the pumps work on an average about 16 hours; under ordinary circumstances, the surface of the filter is uncovered and the sand drained about 8 hours daily. The effluent is pumped to the open distributing reservoir, which is 25 feet deep at the high-water mark and has a capacity of 40,000,000 gallons.

Very frequent analyses, both chemical and bacterial, have been made of the Merrimack River water before and after its passage through the filter, as it leaves the reservoir, and from taps at the City Hall and Experiment Station, which are distant about 1.5 and 2.5 miles, respectively, from the reservoir. A summary of the results of these analyses is presented below.

*Monthly Averages of the Analyses of the Merrimack River Water as it flows on to the Lawrence City Filter.*

[Parts per 100,000.]

| MONTH.           | Temperature.<br>Degrees F. | Color. | AMMONIA. |             |          | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Per Cent. of Dis-<br>solved Oxygen. | Hardness. | Bacteria per Cubic<br>Centimeter. |
|------------------|----------------------------|--------|----------|-------------|----------|-----------|----------------|-----------|------------------|-------------------------------------|-----------|-----------------------------------|
|                  |                            |        | Free.    | ALBUMINOID. |          |           | Nitrates.      | Nitrites. |                  |                                     |           |                                   |
|                  |                            |        |          | Total.      | Soluble. |           |                |           |                  |                                     |           |                                   |
| 1893.            |                            |        |          |             |          |           |                |           |                  |                                     |           |                                   |
| September, . . . | 65                         | .36    | .0113    | .0168       | -        | .22       | .0120          | .0003     | .42              | 80                                  | -         | 57,500                            |
| October, . . .   | 57                         | .27    | .0113    | .0206       | -        | .25       | .0120          | .0004     | .28              | 86                                  | -         | 22,200                            |
| November, . . .  | 42                         | .45    | .0099    | .0212       | -        | .19       | .0170          | .0006     | .47              | 93                                  | -         | 10,800                            |
| December, . . .  | 34                         | .44    | .0056    | .0181       | .0150    | .20       | .0140          | .0001     | .50              | 97                                  | -         | 8,100                             |
| 1894.            |                            |        |          |             |          |           |                |           |                  |                                     |           |                                   |
| January, . . .   | 32                         | .43    | .0075    | .0186       | .0137    | .20       | .0140          | .0001     | .43              | 88                                  | 1.5       | 7,700                             |
| February, . . .  | 32                         | .39    | .0067    | .0182       | .0162    | .21       | .0190          | .0001     | .43              | 93                                  | 1.6       | 7,600                             |
| March, . . .     | 37                         | .48    | .0026    | .0168       | .0143    | .13       | .0110          | .0000     | .45              | 100                                 | 1.0       | 6,500                             |
| April, . . .     | -                          | .42    | .0029    | .0157       | .0147    | .15       | .0110          | .0000     | .40              | 95                                  | 1.3       | 11,200                            |

For additional analyses and notes with regard to turbidity and odor see page 193.

*Monthly Averages of Analyses of Effluent from the City Filter.*

[Parts per 100,000.]

| MONTH.       | Quantity of Effluent.<br>Gallons per Acre Daily. | Temperature.<br>Degrees F. | Color. | AMMONIA. |             |          | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Bacteria per Cubic Centimeter.* |
|--------------|--------------------------------------------------|----------------------------|--------|----------|-------------|----------|-----------|-------------|-----------|------------------|-----------|---------------------------------|
|              |                                                  |                            |        | Free.    | ALBUMINOID. |          |           | Nitrates.   | Nitrites. |                  |           |                                 |
|              |                                                  |                            |        |          | Total.      | Soluble. |           |             |           |                  |           |                                 |
| 1893.        |                                                  |                            |        |          |             |          |           |             |           |                  |           |                                 |
| September, . | 1,389,900                                        | 66                         | .28    | .0072    | .0108       | -        | .23       | .0200       | .0023     | .22              | -         | 6,850                           |
| October, .   | 1,129,800                                        | 58                         | .25    | .0079    | .0113       | -        | .25       | .0350       | .0008     | .19              | -         | 1,216                           |
| November, .  | 1,105,200                                        | 42                         | .37    | .0102    | .0103       | -        | .22       | .0340       | .0004     | .33              | -         | 161                             |
| December, .  | 1,166,300                                        | 35                         | .36    | .0077    | .0113       | .0112    | .20       | .0410       | .0003     | .34              | -         | 111                             |
| 1894.        |                                                  |                            |        |          |             |          |           |             |           |                  |           |                                 |
| January, .   | 1,227,600                                        | 34                         | .34    | .0071    | .0106       | .0102    | .20       | .0370       | .0002     | .31              | 3.0       | 129                             |
| February, .  | 1,218,300                                        | 35                         | .34    | .0090    | .0099       | .0095    | .21       | .0460       | .0001     | .29              | 2.9       | 244                             |
| March, .     | 1,137,200                                        | 39                         | .40    | .0121    | .0093       | .0085    | .18       | .0450       | .0003     | .26              | 3.3       | 455                             |
| April, .     | 996,100                                          | -                          | .38    | .0073    | .0097       | .0093    | .21       | .0370       | .0000     | .31              | 2.7       | 281                             |

\* The bacterial samples in this set of tables correspond as to time of collection to the chemical samples. The results of daily bacterial analyses are given in the tables beyond.

*Monthly Averages of Analyses of Water from the Outlet of the Distributing Reservoir.*

[Parts per 100,000.]

| MONTH.         | Temperature.<br>Degrees F. | Color. | AMMONIA. |             |          | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Bacteria per Cubic<br>Centimeter. |
|----------------|----------------------------|--------|----------|-------------|----------|-----------|-------------|-----------|------------------|-----------|-----------------------------------|
|                |                            |        | Free.    | ALBUMINOID. |          |           | Nitrates.   | Nitrites. |                  |           |                                   |
|                |                            |        |          | Total.      | Soluble. |           |             |           |                  |           |                                   |
| 1893.          |                            |        |          |             |          |           |             |           |                  |           |                                   |
| September, . . | 65                         | .32    | .0077    | .0139       | -        | .22       | .0180       | .0006     | .26              | -         | 556                               |
| October, . .   | 59                         | .26    | .0031    | .0144       | -        | .25       | .0250       | .0004     | .21              | -         | 178                               |
| November, . .  | 44                         | .33    | .0034    | .0126       | -        | .22       | .0250       | .0000     | .32              | -         | 94                                |
| December, . .  | 36                         | .35    | .0055    | .0123       | .0115    | .20       | .0300       | .0001     | .35              | -         | 142                               |
| 1894.          |                            |        |          |             |          |           |             |           |                  |           |                                   |
| January, . .   | 35                         | .35    | .0054    | .0115       | .0104    | .20       | .0320       | .0000     | .33              | 2.7       | 83                                |
| February, . .  | 34                         | .34    | .0055    | .0104       | .0101    | .21       | .0410       | .0000     | .30              | 2.7       | 188                               |
| March, . .     | 38                         | .36    | .0050    | .0097       | .0092    | .20       | .0250       | .0000     | .27              | 2.5       | 179                               |
| April, . .     | -                          | .35    | .0032    | .0093       | .0088    | .19       | .0200       | .0000     | .27              | 2.6       | 137                               |

*Monthly Averages of Analyses of Water from a Tap at the Lawrence City Hall.*

[Parts per 100,000.]

| MONTH.       | Temperature.<br>Degrees F. | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen<br>Consumed. | Hardness. | Bacteria per Cu-<br>bic Centimeter. |
|--------------|----------------------------|--------|----------|-------------|-----------|-------------|-----------|---------------------|-----------|-------------------------------------|
|              |                            |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                     |           |                                     |
| 1893.        |                            |        |          |             |           |             |           |                     |           |                                     |
| September, . | 64                         | .30    | .0035    | .0149       | .22       | .0290       | .0003     | .25                 | -         | 312                                 |
| October, .   | 59                         | .26    | .0025    | .0135       | .24       | .0290       | .0001     | .20                 | -         | 152                                 |
| November, .  | 51                         | .31    | .0032    | .0120       | .22       | .0290       | .0000     | .29                 | -         | 60                                  |
| December, .  | 42                         | .34    | .0039    | .0103       | .20       | .0300       | .0001     | .34                 | -         | 85                                  |
| 1894.        |                            |        |          |             |           |             |           |                     |           |                                     |
| January, .   | 38                         | .35    | .0066    | .0117       | .20       | .0360       | .0000     | .32                 | 2.7       | 51                                  |
| February, .  | 38                         | .33    | .0043    | .0106       | .21       | .0400       | .0000     | .30                 | 2.9       | 102                                 |
| March, .     | 39                         | .36    | .0048    | .0107       | .19       | .0300       | .0000     | .27                 | 2.5       | 92                                  |
| April, .     | -                          | .33    | .0031    | .0101       | .19       | .0300       | .0000     | .27                 | 2.4       | 100                                 |

*Monthly Averages of Analyses of Water from a Tap at the Lawrence Experiment Station.*

[Parts per 100,000.]

| MONTH.         | Temperature.<br>Degrees F. | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen<br>Consumed. | Per Cent of Dis-<br>solved Oxygen. | Hardness. | Bacteria per Cu-<br>bic Centimeter. |
|----------------|----------------------------|--------|----------|-------------|-----------|-------------|-----------|---------------------|------------------------------------|-----------|-------------------------------------|
|                |                            |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                     |                                    |           |                                     |
| 1893.          |                            |        |          |             |           |             |           |                     |                                    |           |                                     |
| September, . . | 63                         | .26    | .0016    | .0136       | .22       | .0800       | .0002     | .23                 | 64                                 | -         | 212                                 |
| October, . . . | 59                         | .24    | .0021    | .0121       | .24       | .0270       | .0000     | .20                 | 79                                 | -         | 140                                 |
| November, . .  | 51                         | .30    | .0020    | .0108       | .22       | .0310       | .0000     | .29                 | 89                                 | -         | 77                                  |
| December, . .  | 42                         | .34    | .0026    | .0106       | .20       | .0340       | .0000     | .34                 | 94                                 | -         | 78                                  |
| 1894.          |                            |        |          |             |           |             |           |                     |                                    |           |                                     |
| January, . . . | 39                         | .35    | .0027    | .0100       | .20       | .0370       | .0000     | .32                 | 95                                 | 2.5       | 50                                  |
| February, . .  | 38                         | .32    | .0036    | .0098       | .21       | .0410       | .0000     | .31                 | 83                                 | 2.9       | 84                                  |
| March, . . . . | 39                         | .34    | .0033    | .0095       | .23       | .0430       | .0000     | .27                 | 80                                 | 2.5       | 150                                 |
| April, . . . . | 45                         | .33    | .0023    | .0096       | .19       | .0340       | .0000     | .27                 | 87                                 | 2.4       | 80                                  |

*Monthly Averages of Daily Bacterial Results from the Lawrence City Water.*

| MONTH.                                                                      | BACTERIA PER CUBIC CENTIMETER IN WATER FROM |                     |                   |                |                         |
|-----------------------------------------------------------------------------|---------------------------------------------|---------------------|-------------------|----------------|-------------------------|
|                                                                             | River.                                      | Effluent at Filter. | Reservoir Outlet. | City Hall Tap. | Experiment Station Tap. |
| <b>1893.</b>                                                                |                                             |                     |                   |                |                         |
| October, . . . . .                                                          | 20,900                                      | 558                 | 146               | 127            | 186                     |
| November, . . . . .                                                         | 7,500                                       | 245                 | 117               | 68             | 71                      |
| December, . . . . .                                                         | 9,800                                       | 200                 | 152               | 92             | 72                      |
| <b>1894.</b>                                                                |                                             |                     |                   |                |                         |
| January, . . . . .                                                          | 7,300                                       | 140                 | 80                | 66             | 63                      |
| February, . . . . .                                                         | 8,200                                       | 250                 | 130               | 88             | 63                      |
| March, . . . . .                                                            | 8,000                                       | 222                 | 220               | 115            | 94                      |
| April, . . . . .                                                            | 14,700                                      | 232                 | 127               | 80             | 78                      |
| Averages, . . . . .                                                         | 10,900                                      | 264                 | 139               | 90             | 82                      |
| Average per cent. of number removed, .                                      | -                                           | 97.58               | 98.73             | 99.17          | 99.25                   |
| Average per cent. of number of river bacteria remaining in water, . . . . . | -                                           | 2.42                | 1.27              | 0.83           | 0.75                    |

In the table above all results are included in the averages. Some of these results were obtained under abnormal conditions, and in the table below are presented averages from which are excluded the results from October 1 to 17, which were obtained before the filter arrived at its normal efficiency; those of November 27, 28 and December 4, when high numbers were present in the effluent, which were doubtless caused by lowering the suction pipe in the pump well and thereby disturbing the sediment which had collected there before the filter was put in use; and the results from February 20 to March 12 when the water passed through a very limited area of the filter.

*Monthly Averages of Bacterial Results showing the Normal Efficiency of the Lawrence City Filter.*

| MONTH.              | BACTERIA PER CUBIC CENTIMETER<br>IN WATER FROM |                        | Per Cent.<br>of Number<br>of River Bacteria<br>which<br>appeared in the<br>Effluent. |
|---------------------|------------------------------------------------|------------------------|--------------------------------------------------------------------------------------|
|                     | River.                                         | Effluent at<br>Filter. |                                                                                      |
| 1893.               |                                                |                        |                                                                                      |
| October, . . . . .  | 8,700                                          | 130                    | 1.50                                                                                 |
| November, . . . . . | 7,200                                          | 177                    | 2.46                                                                                 |
| December, . . . . . | 9,700                                          | 141                    | 1.45                                                                                 |
| 1894.               |                                                |                        |                                                                                      |
| January, . . . . .  | 7,300                                          | 140                    | 1.92                                                                                 |
| February, . . . . . | 8,000                                          | 125                    | 1.56                                                                                 |
| March, . . . . .    | 7,100                                          | 100                    | 1.41                                                                                 |
| April, . . . . .    | 14,700                                         | 232                    | 1.58                                                                                 |
| Averages, . . . . . | 9,000                                          | 150                    | 1.67                                                                                 |

These results show that during this period the normal efficiency of this filter in the removal of bacteria was 98.33 per cent. of the number applied.

In the next table are given the results of the bacterial examination of series of samples of the effluent of the city filter taken at different hours during the day. The pumps were started between 7 and 7.30 A.M. All things taken into consideration, the results are quite uniform under ordinary circumstances. Both the bacterial and the chemical analyses indicate that some ground water at times is mixed with the effluent.

*Table showing the Number of Bacteria per Cubic Centimeter at Different Hours in the Effluent of the Lawrence City Filter.*

| DATE—1894.  | Bacteria in River Water. | BACTERIA IN EFFLUENT. |           |        |        |         |         |       |        |        |        |        |
|-------------|--------------------------|-----------------------|-----------|--------|--------|---------|---------|-------|--------|--------|--------|--------|
|             |                          | 7 A.M.                | 7.30 A.M. | 8 A.M. | 9 A.M. | 10 A.M. | 11 A.M. | 12 M. | 1 P.M. | 2 P.M. | 3 P.M. | 4 P.M. |
| Jan. 8, .   | 8,700                    | 118                   | 148       | 92     | 102    | 85      | 125     | 135   | 138    | 134    | 140    | Lost.  |
| Jan. 15, .  | 9,300                    | —                     | 81        | 106    | 74     | 108     | 103     | 210   | 166    | 140    | 132    | 104    |
| Jan. 16, .  | 7,500                    | 103                   | 102       | 128    | 190    | 245     | 244     | 280   | 249    | 231    | 191    | 162    |
| Jan. 29, .  | 8,700                    | —                     | 85        | 72     | 72     | 109     | 113     | 133   | 168    | 147    | 111    | 97     |
| Feb. 5, .   | 7,800                    | 163                   | 75        | 75     | 88     | 117     | 107     | 148   | 188    | 178    | 184    | 217    |
| Feb. 12, .  | 11,900                   | —                     | 149       | 114    | 63     | 77      | 99      | 135   | 130    | 136    | 175    | 144    |
| Feb. 19, .  | 11,000                   | 129                   | 105       | 161    | 148    | 139     | 138     | 578*  | 448    | 409    | 424    | 454    |
| Feb. 26, .  | 9,300                    | 764                   | 652       | 688    | 640    | 778     | 685     | 648   | 546    | 479    | —      | 344    |
| March 12, . | 9,200                    | 352                   | 334       | —      | 356    | 885     | 890     | 833   | 832    | 750    | 740    | 913    |
| March 19, . | 4,400                    | 97                    | Lost.     | —      | 94     | 92      | 94      | 87    | 89     | 93     | 90     | 98     |
| March 26, . | 4,500                    | —                     | 86        | 97     | 88     | 86      | 73      | 92    | 88     | Lost.  | 92     | 84     |
| April 2, .  | 11,800                   | —                     | —         | —      | 636    | 251     | 272     | 219   | 221    | 205    | 152    | 180    |
| April 9, .  | 21,400                   | —                     | 326       | 185    | 164    | 188     | 212     | 200   | 184    | 190    | 183    | 173    |
| April 16, . | 21,700                   | 280                   | 64        | 110    | 75     | 135     | 89      | 100   | 82     | 105    | 90     | 240    |
| April 23, . | 13,000                   | 178                   | 115       | 145    | 231    | 194     | 157     | 173   | —      | 181    | 151    | 180    |
| April 30, . | 5,900                    | —                     | 116       | 91     | 75     | 94      | 89      | 108   | —      | 80     | 75     | —      |

\* Began to scrape.

The following table shows the number of bacteria in the river water before and after its passage through the filter during the first ten days of its use :—

| DATE—1893.      | BACTERIA PER CUBIC CENTIMETER. |                          |
|-----------------|--------------------------------|--------------------------|
|                 | River Water.                   | Effluent of City Filter. |
| September 20, . | 3,200                          | 3,600                    |
| 22, .           | 20,300                         | 13,500                   |
| 23, .           | 19,000                         | 15,700                   |
| 25, .           | 17,000                         | 3,500                    |
| 26, .           | 6,400                          | 3,600                    |
| 27, .           | 22,000                         | 5,600                    |
| 29, .           | 44,300                         | 4,100                    |
| 29, .           | 93,000                         | 2,600                    |
| 30, .           | 108,000                        | 3,600                    |

*Daily Bacterial Results, Lawrence City Water.*

[Bacteria per cubic centimeter.]

| DATE—1893.           | In River Water. | IN FILTERED WATER FROM |                   |                   |                            |
|----------------------|-----------------|------------------------|-------------------|-------------------|----------------------------|
|                      |                 | Filter.                | Reservoir Outlet. | Tap at City Hall. | Tap at Experiment Station. |
| October 1, . . . . . | -               | -                      | -                 | -                 | -                          |
| 2, . . . . .         | 34,800          | 700                    | 370               | 290               | 250                        |
| 3, . . . . .         | 36,000          | 1,500                  | 408               | 240               | 330                        |
| 4, . . . . .         | 22,300          | 2,200                  | 252               | 318               | 306                        |
| 5, . . . . .         | 16,500          | 1,000                  | 235               | 145               | 276                        |
| 6, . . . . .         | 10,300          | 240                    | 156               | 120               | 110                        |
| 7, . . . . .         | 33,000          | 300                    | 143               | 134               | 98                         |
| 8, . . . . .         | -               | -                      | -                 | -                 | -                          |
| 9, . . . . .         | 9,500           | 726                    | 162               | 160               | 122                        |
| 10, . . . . .        | 24,000          | 960                    | 103               | 119               | 66                         |
| 11, . . . . .        | 48,800          | 1,920                  | 115               | 108               | 101                        |
| 12, . . . . .        | 55,200          | 880                    | 123               | 122               | 110                        |
| 13, . . . . .        | 44,400          | 448                    | 145               | 129               | 85                         |
| 14, . . . . .        | 60,000          | 266                    | 120               | 100               | 110                        |
| 15, . . . . .        | -               | -                      | -                 | -                 | -                          |
| 16, . . . . .        | -               | -                      | -                 | -                 | 102                        |
| 17, . . . . .        | 12,500          | 810                    | 112               | 126               | 121                        |
| 18, . . . . .        | 10,500          | 228                    | 100               | 100               | 146                        |
| 19, . . . . .        | 9,200           | 110                    | 105               | 80                | 97                         |
| 20, . . . . .        | 5,500           | 180                    | 102               | 80                | 80                         |
| 21, . . . . .        | 6,200           | 82                     | 70                | 92                | 90                         |
| 22, . . . . .        | -               | -                      | -                 | -                 | -                          |
| 23, . . . . .        | 2,500           | 126                    | 97                | 68                | 117                        |
| 24, . . . . .        | 4,800           | 100                    | 77                | 89                | 130                        |
| 25, . . . . .        | 23,000          | 131                    | 110               | 100               | 180                        |
| 26, . . . . .        | 18,000          | 160                    | 112               | 98                | 104                        |
| 27, . . . . .        | 5,000           | 110                    | 90                | 76                | 122                        |
| 28, . . . . .        | 6,100           | 65                     | 126               | 90                | 100                        |
| 29, . . . . .        | -               | -                      | -                 | -                 | -                          |
| 30, . . . . .        | -               | -                      | -                 | -                 | 95                         |
| 31, . . . . .        | 4,900           | 143                    | 84                | 76                | 85                         |

Total quantity of effluent for month, 87,556,523 gallons.

The surface was scraped about  $\frac{1}{4}$  inch deep as follows: the 2 lower beds, October 14; the next 4, October 21; the next 17, October 28; and the remaining 5, October 31.



*Daily Bacterial Results, Lawrence City Water—Continued.*

[Bacteria per cubic centimeter.]

| DATE—1894.       | In River Water. | IN FILTERED WATER FROM |                   |                   |                            | Condition of Surface when Pumps were Stopped. | Loss of Head.<br>—<br>Feet. |
|------------------|-----------------|------------------------|-------------------|-------------------|----------------------------|-----------------------------------------------|-----------------------------|
|                  |                 | Filter.                | Reservoir Outlet. | Tap at City Hall. | Tap at Experiment Station. |                                               |                             |
| January 1, . . . | 4,500           | —                      | —                 | —                 | 80                         | Covered.                                      | —                           |
| 2, . . .         | 5,900           | 75                     | 123               | 53                | 96                         | Drained.                                      | —                           |
| 3, . . .         | 3,600           | —                      | 98                | 60                | 52                         | "                                             | —                           |
| 4, . . .         | 7,500           | 75                     | 72                | 53                | 51                         | "                                             | —                           |
| 5, . . .         | 6,000           | —                      | 78                | 50                | 76                         | "                                             | —                           |
| 6, . . .         | 5,500           | 195                    | —                 | 55                | 94                         | Covered.                                      | —                           |
| 7, . . .         | —               | —                      | —                 | —                 | —                          | "                                             | —                           |
| 8, . . .         | 8,700           | 122                    | 98                | 45                | 77                         | "                                             | —                           |
| 9, . . .         | 6,600           | 88                     | 104               | 77                | 83                         | "                                             | —                           |
| 10, . . .        | 7,100           | 80                     | 114               | 56                | 61                         | "                                             | —                           |
| 11, . . .        | 6,800           | —                      | 94                | 46                | 60                         | "                                             | —                           |
| 12, . . .        | 7,400           | 115                    | 73                | 39                | 94                         | Drained.                                      | —                           |
| 13, . . .        | 8,200           | 137                    | 82                | 72                | 78                         | Covered.                                      | 3.1                         |
| 14, . . .        | —               | —                      | —                 | —                 | —                          | "                                             | —                           |
| 15, . . .        | 9,300           | 102                    | 90                | 71                | 84                         | "                                             | 2.9                         |
| 16, . . .        | 7,600           | 193                    | 94                | 60                | 82                         | Drained.                                      | 3.8                         |
| 17, . . .        | 7,700           | 141                    | 96                | 51                | 57                         | Covered.                                      | 3.7                         |
| 18, . . .        | 7,400           | 260                    | 98                | 71                | 63                         | Drained.                                      | 3.0                         |
| 19, . . .        | 10,500          | 183                    | 77                | 65                | 62                         | "                                             | 3.7                         |
| 20, . . .        | 6,100           | 152                    | 73                | 70                | 58                         | "                                             | 3.5                         |
| 21, . . .        | —               | —                      | —                 | —                 | —                          | Covered.                                      | —                           |
| 22, . . .        | 7,500           | 158                    | 51                | 68                | 45                         | "                                             | 2.9                         |
| 23, . . .        | 8,600           | 162                    | 56                | 60                | 77                         | Drained.                                      | 3.5                         |
| 24, . . .        | 5,900           | 145                    | 34                | 44                | 33                         | "                                             | 3.8                         |
| 25, . . .        | 8,600           | 102                    | 52                | 25                | 40                         | "                                             | 2.0                         |
| 26, . . .        | 6,300           | 117                    | 50                | 31                | 30                         | Covered.                                      | 3.2                         |
| 27, . . .        | 6,900           | 131                    | 74                | 40                | 42                         | "                                             | 2.8                         |
| 28, . . .        | —               | —                      | —                 | —                 | —                          | "                                             | —                           |
| 29, . . .        | 9,600           | 112                    | 55                | 52                | 54                         | "                                             | 3.0                         |
| 30, . . .        | 7,000           | 137                    | 78                | 62                | 34                         | Drained.                                      | 3.0                         |
| 31, . . .        | 9,800           | 208                    | 74                | 65                | 38                         | "                                             | 3.1                         |

Total quantity of effluent for month, 95,138,259 gallons.

*Daily Bacterial Results, Lawrence City Water—Continued.*

[Bacteria per cubic centimeter.]

| DATE—1894.        | In River Water. | IN FILTERED WATER FROM |                   |                   |                            | Condition of Surface when Pumps were Stopped. | Loss of Head.—<br>Feet. |
|-------------------|-----------------|------------------------|-------------------|-------------------|----------------------------|-----------------------------------------------|-------------------------|
|                   |                 | Filter.                | Reservoir Outlet. | Tap at City Hall. | Tap at Experiment Station. |                                               |                         |
| February 1, . . . | 6,300           | 86                     | 56                | 39                | 51                         | Covered.                                      | 3.6                     |
| 2, . . .          | 7,700           | 59                     | 63                | 26                | 54                         | "                                             | 3.6                     |
| 3, . . .          | 5,600           | 102                    | 55                | 22                | 50                         | "                                             | 3.5                     |
| 4, . . .          | —               | —                      | —                 | —                 | —                          | "                                             | —                       |
| 5, . . .          | 7,800           | 146                    | 90                | 72                | 33                         | "                                             | 3.6                     |
| 6, . . .          | 10,200          | 159                    | 41                | 62                | 50                         | "                                             | 3.8                     |
| 7, . . .          | 9,000           | 110                    | 51                | 35                | 61                         | Drained.                                      | 3.9                     |
| 8, . . .          | 7,800           | —                      | 70                | 48                | 40                         | "                                             | 5.1                     |
| 9, . . .          | 7,500           | 101                    | 67                | 58                | 37                         | "                                             | 4.6                     |
| 10, . . .         | 7,800           | 151                    | 75                | 55                | 19                         | "                                             | 4.8                     |
| 11, . . .         | —               | —                      | —                 | —                 | —                          | "                                             | —                       |
| 12, . . .         | 11,900          | 115                    | 49                | 90                | 53                         | Covered.                                      | 4.8                     |
| 13, . . .         | 7,100           | 130                    | 60                | 95                | 35                         | "                                             | 4.4                     |
| 14, . . .         | 7,100           | 125                    | 67                | 72                | 43                         | "                                             | 4.0                     |
| 15, . . .         | 6,600           | 105                    | 70                | 63                | 58                         | "                                             | 6.2                     |
| 16, . . .         | 8,100           | 163                    | 63                | 56                | 64                         | "                                             | 6.0                     |
| 17, . . .         | 7,000           | —                      | 98                | 88                | 30                         | Drained.                                      | 7.0                     |
| 18, . . .         | —               | —                      | —                 | —                 | —                          | "                                             | —                       |
| 19, . . .         | 10,700          | 140                    | 90                | 66                | 30                         | "                                             | 7.6                     |
| 20, . . .         | 11,200          | 460                    | 95                | 58                | 62                         | "                                             | 6.8                     |
| 21, . . .         | 9,300           | 396                    | 157               | 118               | 68                         | "                                             | 7.7                     |
| 22, . . .         | 8,600           | —                      | —                 | 110               | 80                         | "                                             | 7.6                     |
| 23, . . .         | 7,000           | 387                    | 254               | 122               | 60                         | Covered.                                      | 7.4                     |
| 24, . . .         | 9,400           | 529                    | 281               | 185               | 90                         | Drained.                                      | 6.9                     |
| 25, . . .         | —               | —                      | —                 | —                 | —                          | "                                             | 7.3                     |
| 26, . . .         | 9,900           | 623                    | 356               | 248               | 189                        | "                                             | 7.0                     |
| 27, . . .         | 7,100           | 682                    | 411               | 152               | 142                        | "                                             | 7.2                     |
| 28, . . .         | 6,500           | 438                    | 345               | 165               | 116                        | "                                             | 7.0                     |

Total quantity of effluent for month, 85,279,992 gallons.

On February 19 there were about 2 feet of ice on the surface, and in places on the side opposite from the main distributing conduit it was frozen to the sand considerable air was in the pores of the sand. During the next 10 days a strip about 6 feet in width was scraped along each lateral conduit for about two-thirds the width of the filter.

*Daily Bacterial Results, Lawrence City Water — Continued.*

[Bacteria per cubic centimeter.]

| DATE — 1894.     | In River Water. | IN FILTERED WATER FROM |                   |                   |                            | Condition of Surface when Pumps were Stopped. | Loss of Head. — Feet. |
|------------------|-----------------|------------------------|-------------------|-------------------|----------------------------|-----------------------------------------------|-----------------------|
|                  |                 | Filter.                | Reservoir Outlet. | Tap at City Hall. | Tap at Experiment Station. |                                               |                       |
| March 1, . . . . | 6,500           | 350                    | 284               | 211               | 180                        | Drained.                                      | 7.0                   |
| 2, . . . .       | 9,900           | 410                    | 346               | 167               | 116                        | "                                             | 6.4                   |
| 3, . . . .       | 5,000           | 588                    | 295               | 186               | 179                        | "                                             | 6.2                   |
| 4, . . . .       | —               | —                      | —                 | —                 | —                          | "                                             | 5.5                   |
| 5, . . . .       | 7,000           | —                      | 408               | 185               | 100                        | "                                             | 5.7                   |
| 6, . . . .       | 12,200          | 395                    | 306               | 162               | 104                        | "                                             | 5.5                   |
| 7, . . . .       | 16,000          | 360                    | 420               | 170               | 88                         | "                                             | 5.8                   |
| 8, . . . .       | 18,400          | —                      | 390               | 182               | 74                         | "                                             | 4.3                   |
| 9, . . . .       | 13,000          | —                      | 270               | 170               | 65                         | "                                             | 5.8                   |
| 10, . . . .      | 13,000          | 325                    | 310               | 140               | 280                        | "                                             | 5.9                   |
| 11, . . . .      | —               | —                      | —                 | —                 | —                          | "                                             | —                     |
| 12, . . . .      | 9,200           | 711                    | 262               | 110               | 89                         | "                                             | 4.3                   |
| 13, . . . .      | 9,800           | —                      | 270               | 128               | 189                        | "                                             | 6.4                   |
| 14, . . . .      | 8,600           | —                      | 240               | 98                | 112                        | "                                             | 6.6                   |
| 15, . . . .      | 7,800           | —                      | 290               | 117               | 68                         | "                                             | 5.7                   |
| 16, . . . .      | 7,200           | 198                    | 287               | 191               | 90                         | "                                             | 6.0                   |
| 17, . . . .      | 5,000           | 165                    | 262               | 72                | 71                         | "                                             | 3.9                   |
| 18, . . . .      | —               | —                      | —                 | —                 | —                          | "                                             | —                     |
| 19, . . . .      | 4,400           | 93                     | 116               | 78                | 40                         | "                                             | 3.9                   |
| 20, . . . .      | 7,000           | 99                     | 103               | 50                | 50                         | "                                             | 5.3                   |
| 21, . . . .      | 5,000           | 98                     | 124               | 48                | 58                         | "                                             | 5.2                   |
| 22, . . . .      | 3,000           | 75                     | 195               | 36                | 53                         | "                                             | 5.5                   |
| 23, . . . .      | 8,100           | 76                     | 107               | 46                | 36                         | "                                             | 5.5                   |
| 24, . . . .      | 5,000           | 65                     | 76                | 42                | 57                         | "                                             | 5.3                   |
| 25, . . . .      | —               | —                      | —                 | —                 | —                          | "                                             | —                     |
| 26, . . . .      | 4,500           | 87                     | 94                | 48                | 80                         | "                                             | 5.2                   |
| 27, . . . .      | 3,500           | 110                    | 73                | 53                | 81                         | "                                             | 5.7                   |
| 28, . . . .      | 3,000           | 83                     | 103               | 57                | 32                         | "                                             | 5.6                   |
| 29, . . . .      | 2,000           | 74                     | 93                | 136               | 53                         | "                                             | 5.4                   |
| 30, . . . .      | 8,700           | 78                     | 110               | 122               | 96                         | "                                             | 5.4                   |
| 31, . . . .      | 10,200          | —                      | 90                | 120               | 86                         | "                                             | 5.1                   |

Total quantity of effluent for month, 88,132,232 gallons.

The ice had disappeared by March 12 and the surface was gradually scraped and graded. This took about a month, and was the third complete scraping of the surface.

*Daily Bacterial Results, Lawrence City Water — Concluded.*

[Bacteria per cubic centimeter.]

| DATE — 1894.     | In River Water. | IN FILTERED WATER FROM |                   |                   |                            | Condition of Surface when Pumps were Stopped. | Loss of Head. — Feet. |
|------------------|-----------------|------------------------|-------------------|-------------------|----------------------------|-----------------------------------------------|-----------------------|
|                  |                 | Filter.                | Reservoir Outlet. | Tap at City Hall. | Tap at Experiment Station. |                                               |                       |
| April 1, . . . . | —               | —                      | —                 | —                 | —                          | Drained.                                      | —                     |
| 2, . . . .       | 11,300          | 230                    | 183               | 197               | 94                         | "                                             | 3.0                   |
| 3, . . . .       | 7,300           | 101                    | 112               | 70                | 76                         | "                                             | 4.7                   |
| 4, . . . .       | 10,000          | 337                    | 210               | 137               | 110                        | "                                             | 4.6                   |
| 5, . . . .       | 22,500          | 160                    | 70                | 62                | 136                        | "                                             | 4.6                   |
| 6, . . . .       | 9,300           | 140                    | 131               | 68                | 98                         | "                                             | 4.8                   |
| 7, . . . .       | 19,200          | 350                    | 218               | 75                | 78                         | "                                             | 4.3                   |
| 8, . . . .       | —               | —                      | —                 | —                 | —                          | Covered.                                      | —                     |
| 9, . . . .       | 21,000          | 195                    | 152               | 78                | 80                         | Drained.                                      | 4.0                   |
| 10, . . . .      | 16,800          | 170                    | 136               | 83                | 75                         | "                                             | 4.7                   |
| 11, . . . .      | 23,000          | 198                    | 134               | 82                | 76                         | "                                             | 4.6                   |
| 12, . . . .      | 19,200          | 798                    | 196               | 86                | 68                         | "                                             | 4.7                   |
| 13, . . . .      | 22,100          | 720                    | 170               | 88                | 76                         | "                                             | 4.8                   |
| 14, . . . .      | 18,000          | 350                    | 158               | 89                | 68                         | "                                             | 4.7                   |
| 15, . . . .      | —               | —                      | —                 | —                 | —                          | "                                             | —                     |
| 16, . . . .      | 21,700          | 108                    | 165               | 100               | 83                         | "                                             | 3.5                   |
| 17, . . . .      | 8,300           | 85                     | 95                | 125               | 95                         | "                                             | 3.9                   |
| 18, . . . .      | 15,200          | —                      | 160               | 40                | 85                         | "                                             | 4.0                   |
| 19, . . . .      | 12,000          | —                      | —                 | 60                | 55                         | "                                             | 4.4                   |
| 20, . . . .      | 15,100          | 121                    | 127               | 72                | 59                         | "                                             | 4.8                   |
| 21, . . . .      | 25,400          | 180                    | 75                | 47                | 64                         | "                                             | 4.7                   |
| 22, . . . .      | —               | —                      | —                 | —                 | —                          | "                                             | —                     |
| 23, . . . .      | 13,000          | 170                    | 96                | 83                | 60                         | "                                             | 2.8                   |
| 24, . . . .      | 12,100          | 190                    | 84                | 54                | 67                         | "                                             | 3.4                   |
| 25, . . . .      | 6,300           | 226                    | 88                | 73                | 67                         | "                                             | 3.7                   |
| 26, . . . .      | 11,400          | 215                    | 68                | 76                | 58                         | "                                             | 3.9                   |
| 27, . . . .      | 7,800           | 91                     | 76                | 56                | 70                         | "                                             | 3.9                   |
| 28, . . . .      | 5,400           | 110                    | 66                | 64                | 67                         | "                                             | 4.4                   |
| 29, . . . .      | —               | —                      | —                 | —                 | —                          | Covered.                                      | —                     |
| 30, . . . .      | 5,900           | 98                     | 68                | 50                | 90                         | "                                             | 3.1                   |

Total quantity of effluent for month, 74,706,793 gallons.



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THE FILTER

OF THE

WATER SUPPLY OF THE CITY OF  
LAWRENCE

AND ITS RESULTS.

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By HIRAM F. MILLS, A.M., C.E.,  
MEMBER OF THE STATE BOARD OF HEALTH OF MASSACHUSETTS.

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# THE FILTER OF THE WATER SUPPLY OF THE CITY OF LAWRENCE AND ITS RESULTS.

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MEMBER OF THE STATE BOARD OF HEALTH OF MASSACHUSETTS.

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The Lawrence pumping station is by the side of the Merrimack River above the city and about a thousand feet up stream from the nearest house. The water was drawn from the river through a thirty-inch iron pipe continued to the engine house by a brick conduit four feet in diameter. At right angles with this conduit, and extending down stream from the engine house for three hundred feet along the shore, was a stone and brick filter-gallery eight feet wide and eight feet high inside, the bottom of which, as well as the bottom of the conduit from the river, was about level with the bottom of the pump well under the engine house and eleven feet below low water in the river.

The river water brought so much silt at the time of the spring and fall freshets that the shore became impermeable, and soon after the works were constructed it became evident that the filter-gallery received little or no water from the river side and the quantity received from the land side was insignificant. The works have been in use about seventeen years. For some years after they were built there was a diminution in the number of deaths by typhoid fever from the number when well water was used, and no one thought of direct poisoning by sewage of the water taken from the river nine miles below Lowell with a fall of ten feet through a rapid a mile long on the way. Many made the remark that running water purified itself in a less distance and put away any fear of contamination, while a few did not like to drink water into which the sewage of seventy thousand people was poured only eight hours before it reached the intake of the water works.

Shortly after the State Board of Health was reorganized in 1886 the Experiment Station was established at Lawrence, and it was soon found that all of the bacteria in sewage, amounting generally to



several hundred thousand in every thimbleful, could be removed by slow intermittent filtration; also, that the same result could be attained by filtering water at a more rapid rate, but not at a rate that rendered it practicable to apply to a city's water supply. Experiments of the Board with rapid mechanical filters showed a large percentage of the bacteria remaining in the filtered water, and experiments at Berlin indicated that the continuous filters of that city allowed some of the germs of typhoid fever to pass through; enough to cause sickness in the city.

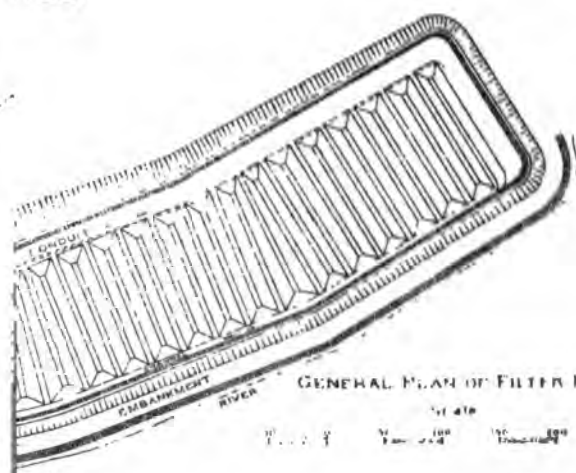
In 1890 a careful study of the deaths from typhoid fever in the cities of the State showed that the cities of Lowell and Lawrence had nearly three times the average number, from the same population, in other cities; and that during the season — August, September and October — when other cities had the most typhoid fever, Lowell and Lawrence had about the same number as other cities, but a month or more later the deaths in Lowell reached three and four and eight times the deaths in other cities, and after another month those of Lawrence increased by a still greater ratio, so that in some years the deaths in January and February from this disease were more than the actual number in Boston, with ten times the population. This condition, following year after year, made it so evident that the disease came down the river to Lowell from the cities and towns above, and then came with greater intensity from Lowell to Lawrence, that the State Board of Health made strenuous efforts to produce a filter that would remove all disease-producing germs that could be applied to it, and at the same time filter rapidly enough to serve for a city's water supply. Billions of typhoid-fever germs were cultivated and applied to filters of different construction, and in 1891 we succeeded in removing all that were applied when filtering two million gallons per acre daily. Then the Board advised the city of Lawrence to filter its water, and offered to show how to do it.

Such a filter would require some layers of quite fine sand, and it was thought necessary to first take out the very fine river silt from the water by means of a coarser sand filter at the river bank. Further experiments showed that the construction of a filter at the river bank with a sand coarse enough to allow the river silt to be deposited upon it, if removed promptly, would serve to remove ninety-eight per cent. of all of the bacteria of the river water and a still larger per cent. of the disease producing germs; and considera-



SECTION ON E. E.

ASS.



10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330 340 350 360 370 380 390 400 410 420 430 440 450 460 470 480 490 500 510 520 530 540 550 560 570 580 590 600 610 620 630 640 650 660 670 680 690 700 710 720 730 740 750 760 770 780 790 800 810 820 830 840 850 860 870 880 890 900 910 920 930 940 950 960 970 980 990 1000



tions of economy and the immense advantage of such a filter with the probability of this or none, with an unbelieving public, induced the State Board of Health to advise the city to immediately construct such a filter and save the fifty-seven lives, which was the annual excess of deaths by this disease over that of the same number of inhabitants in cities of the State having a good water supply.

In 1892, in view of the possibility of cholera getting into Lowell and making it necessary to cut off the Lawrence water supply, the city government made an appropriation for beginning the work of constructing the filter in accordance with the advice of the State Board of Health and under its direction.

The general design was to excavate the bed and bank of the river to seven feet below low water for a width of about one hundred and fifty feet out from the old filter-gallery and from the high water shore down stream from this, making a length of about seven hundred and fifty feet and an area of excavation of two and one-half acres (see Plate I., Fig. 7). The suitable material from the excavation was to be put into a tight embankment, on the ends and river side, carried to nine feet above low water in the river or high enough to exclude the highest freshets. The excavation was to be then filled for a depth of about five feet with suitable filtering sand properly underdrained into the old filter-gallery and into a small perforated conduit in extension of the gallery.

The top of the sand, being two feet below low water in the river, could by a proper inlet be flooded by gravity to a depth of about two feet, thus forming a shallow pond of two and a half acres area, which would gradually filter downward through the sand to the underdrains and be conveyed to the old gallery, and through this to the pump-well.

One of the essential qualities of the design required that the inlet water should be shut off once a day and the pumps kept running until the sand was uncovered and the water within the sand drawn out, so that the sand could fill with air from top to bottom.

This condition of filling the sand with air daily was regarded necessary to insure the burning up of the organic matter which penetrated the sand below the surface and forming nitrates in the water, thus producing conditions the most unfavorable for the continuation of the life of bacteria within the water in their passage through the sand and in the water after leaving the filter.

There is nearly air enough in our drinking waters to supply the

oxygen which is necessary to carry on the process of nitrification when the water comes in contact with the grains of sand which have nitrifying bacteria adherent, but the addition of the air which enters the sand by drawing the water out of it once a day causes a more complete burning up of the organic matter in the water, which is the nitrifying process spoken of.

The question may arise, if water contains so much air why does not nitrification take place in the reservoir? The reason is that nitrification will not take place unless the water with the air comes in contact with certain bacteria which in some unknown way cause the process to be carried on. These bacteria attach themselves to the grains of sand of the filter and remain there, and when air is present they can in a short time cause the nitrifying process to be carried on so completely that nearly all of the organic matter in the water is burnt up, and with this burning the disease germs in the water are killed.

The carrying out of this design required some original investigations upon the head required to convey a definite quantity of water through sands of different size of grain and through gravel stones of different sizes. The circumstances of the location would allow an expenditure of head of one and a half feet when the surface of the sand was clean, through the sand and through the underdrains and conduit to the pump-well, when drawing the full quantity of 2,000,000 gallons per acre per day, or 5,000,000 gallons for the field.

The sand selected to meet these conditions was of two sizes, the finer of the two being placed directly over the underdrains and for five feet each side of them; and the coarser occupying the remaining twenty feet between the drains, and through which the water would move laterally and use up about the same amount of head as when flowing directly downward through the finer sand.

The coarser sand was such that 70,000,000 gallons would flow in twenty-four hours through a foot in depth, covering an acre, with the expenditure of one foot head; and the finer sand would convey 50,000,000 gallons under the same conditions. In moving vertically downward five feet through the finer sand, 10,000,000 gallons would flow through with the expenditure of one foot of head, but the water moving laterally through the coarser sand toward the underdrain would crowd the stream in the finer sand below the surface so that the water going through the surface in a width of ten feet would

be, near the bottom, pressed into a channel of perhaps not more than five feet in width and thus decreasing the quantity that could pass with one foot head to perhaps 7,000,000 gallons per acre per day.

As the water was to flow through the sand with a daily intermission of several hours, the actual time of flowing would be, say two-thirds of the day, and would allow between four and five millions to pass. This is the quantity that could pass with one foot loss of head through the sand when the surface of the sand is clean, but the fine mineral sediment and the organic matter brought by the river water choke the surface and reduce the quantity of water that can pass through, and in order not to have to clean the surface too frequently, the sand when clean should be able to convey two or three times the quantity required.

It was expected, from experiments that had been made with this water, that ordinarily with sand grains of the sizes here used, the surface would have to be cleaned by removing from an eighth to a quarter of an inch and replacing with clean sand once a month, and that during freshets, when more sediment comes in the river water, the surface would have to be cleaned oftener.

If the surface should not be cleaned as often as necessary, the result would be a lowering of water in the pump-well and if neglected until the surface became so impervious that the one or two feet in depth of water over the surface were not sufficient to force the required quantity through the upper layer, the drawing down of the pump well to the bottom of the sand would give no relief, the surface would have to be cleaned.

Economy of construction, the providing for a nearly uniform rate of filtration through every square foot of the area of the filter, and applying the water to the surface of the sand in a valley so that as it is filled daily there will not be a current over the surface of the sand sufficiently rapid to move the sand grains, caused the following section to be adopted.

The underdrains were arranged to be thirty feet apart. The excavation was not made to a uniform depth of seven feet below low water in the river, but was made to the depth of eight feet for a width of five feet where the underdrains were to be, and to the depth of six feet for a width of five feet at ridges between the underdrains, with slopes of one foot in ten feet between (see Plate I., Figs. 3, 4, 5 and 6). Over these ridges the sand was filled only to the depth of three feet for a width of five feet and beyond this the surface of the

sand rose one foot in twenty feet and then ran level for five feet at a height of six feet above the bottom. Such ridges and hollows formed the general longitudinal section of the bed.

The direct conduit through which water was formerly supplied to the pump-well from the river is at the up-river end of the filter-bed (Plate I., Fig. 1). It is furnished with a gate at the inner end, and the top was pierced and a chimney built about forty feet outside of the engine house, and projecting through the side of this chimney were set two iron pipes two feet in diameter with a gate in each, having its centre two feet below low water in the river. One of these is intended to supply an extension of the works up the river; the other discharges into an open conduit which extends along the inside of the embankment nearly the whole length of the bed. At the upper end the section is a semi-circle six feet in diameter. The edge toward the bed remains level throughout its length at three feet below low water of the river, but the bottom rises gradually from three feet below the edge to six inches below at the lower end, and this continues by a curve and crosses the bed in the down-river valley with the edges level, but the bottom rises so that the depth at the end is only one inch. In each of the valleys, thirty feet apart, extends from this main conduit a shallow carrier of concrete lined with cement mortar, having its edges level with the edge of the conduit, and extending from the conduit to thirty-two feet from the opposite side of the bed. These are two feet wide and three inches deep at the conduit, and one foot wide and one inch deep at the end. In this way there are formed edges of water carriers at the same level and about one and one-third miles in length, over which the water reaches the sand, and as within two feet from these edges the surface of the sand rises with a slope one foot in ten there is very little perceptible current over the sand as the water leaves the carriers.

The conduit is made of cobble paving stones four to six inches through, laid in Portland cement mortar on a layer of gravel eight inches thick and made smooth within by a coat of mortar. The carriers are made of cobble stones about four inches in diameter, laid in Portland cement mortar on the sand, and made smooth within. At the junction with the conduit the carriers are widened by curves to prevent washing of sand at the turn.

The underdrains enter the old filter-gallery through holes cut in the wall. (See Plate I., Fig. 2.) Glazed sewer pipe surrounded by stones are used for about four-tenths of the distance from the

gallery across the bed, beyond which are layers of stones of different sizes without pipes. Beginning at the gallery is one length of ten-inch pipe, then two lengths of eight-inch pipe, then from thirty-five to sixty-five feet of six-inch pipe, ending with three lengths of four-inch pipe. These pipes are laid apart so that the spigot approaches but does not enter the bell, and they are surrounded by a layer of about four inches of stones about two inches in diameter. (See Plate I., Figs. 3, 4, 5 and 6.) Other layers, decreasing in size through one and one-half inches, three-quarters of an inch, three-eighths of an inch and three-sixteenths of an inch, are applied in the form shown by the sections and plans, and the latter being spread out to a width of seventeen feet is covered by one inch of coarse mortar sand which spreads to a width of twenty feet. Upon this rests the filtering sand from four to five feet deep.

The valley in the excavation is deepened in the part occupied by the pipe so that the pipe has a slope of one foot in one hundred feet. The pipe was applied as far from the filter-gallery, or conduit in extension of the gallery, as it and the stones surrounding it cost less than the much larger area of stones required to give the desired freedom of flow. Beyond this the large stones were spread out to the widths and with the depths required to give the desired flow.

To determine how much head would be used in flowing through layers of sand and layers of stones of different sizes experiments were made under my direction by Mr. Allen Hazen, the chemist in charge of the Experiment Station of the State Board of Health. As is well known, the head required to convey water through ordinary pipes varies with the square of the velocity, but with extremely small pipes and through the interstices of fine sand the head required to convey water varies with the velocity and with the temperature, more head being required with colder water. Through coarse sand and through gravel stones the head varies with powers of the velocity between the first and second powers, increasing with the size of the grains or of the stones. For sands, ten per cent. of whose grains are as small as two millimeters or eight-hundredths of an inch in diameter, the quantities of water that would pass through an acre in area with different depths and sizes of grains were determined by the following formula deduced from experiments which had been made up to the time of constructing this filter:  $Q = \frac{800}{l} h^{1.42}$  in which  $Q$  expresses the quantity of water in million gallons per acre per day,  $h$  the acting head in feet,  $l$  the distance flowing through the sand in



feet, and  $d$  the maximum diameter in millimeters of the finer ten per cent. of the sand grains.

This formula expresses quite satisfactorily the quantity of water that will pass through clean sand from which air has been pushed out when the temperature is about 50° Fah., and is convenient to use in comparing sands of different sizes; but Mr. Hazen found that the resistance was nearly twice as great when the temperature was near the freezing point as when at summer heat, and he afterward determined an expression from the experiments, giving the velocity of flow through sands at any temperature, which may be found on page 553 of the Report of the State Board of Health for 1892.

The sand used in the Lawrence filter which was placed directly over the underdrains and five feet on either side had the coarser grains of the finer ten per cent. twenty-five hundredths of a millimeter in diameter, and by the above formula when the head used is equal to the distance which the water passes through the sand the quantity of water that could pass through an acre in twenty-four hours would be fifty million gallons. If two million gallons were applied to an acre in sixteen hours, or the equivalent of three million gallons in twenty-four hours, and this were crowded into one-half its area near the bottom of the sand, by the lateral pressure of the water coming towards the underdrains through the ten feet of coarser sand on each side, the resistance would be like that of four and a half million gallons traversing six feet in depth of sand, for which the head required would be fifty-four hundredths of a foot.

As the circumstances here allowed of a loss of head through the sand of one foot, the remaining head, from fifty-four hundredths to one foot, was the amount allowed for increased obstruction through the sand due to air and to lower temperature.

By a similar process of computation the coarser sand occupying the remaining twenty feet of the thirty feet between underdrains was found to be able to convey its proportion of the water to the underdrains with a like loss of head; hence the arrangement presented by these sections enabled all parts of the area of the filter to transmit nearly their proper quantity of water.

With this loss of head through the sand when clean, there would be a noticeable increase in loss by a slight deposit of sediment upon the surface, and depending upon this narrow margin it was deemed practicable to construct and use for a term of years a single bed which was to be cleaned regularly each month, a portion being

cleaned every day during the interval when the bed is resting; and this portion when cleaned is not capable of conveying so large a quantity of water that it cannot be properly purified in its passage, unless there be an extreme drawing down of the head which would require very close watching at the pumps.

When it becomes impracticable to properly purify the full amount of the city's supply by the present bed it is designed to construct another bed extending up the river from the intake, to be supplied by the second two-foot valve mentioned as built into the side of the chimney rising from the old intake.

We have followed the water through the sand and considered the head lost in its passage. There is still some head to be used in passing through the layers of stone and the underdraining pipes.

In considering the loss of head through fine sand and through coarser material to very large gravel stones, we find the loss increasing with the first power of the velocity, and with powers increasing with the coarseness from the first to the second power of the velocity; hence the most convenient method of presenting what our experiments have shown is in the form of a table which was used in distributing the remaining allowable loss of head of about half a foot in addition to the one foot through the sand, so that it should still serve to make the passage of water nearly uniform from all portions of the surface of the bed.

This table, though capable of improvement by additional data, led to conclusions which proved satisfactory in this case.

*Quantity of Water Flowing through Gravel Stones at Different Heads.*

[Quantity flowing in 1,000,000 gallons per acre daily.]

| LOSS OF HEAD IN<br>TERMS OF DISTANCE<br>THROUGH GRAVEL. | SIZE OF GRAVEL STONES IN MILLIMETERS AND INCHES, THE FINEST 10 PER CENT.<br>FINER THAN— |                   |                   |                    |                    |                   |                   |                   |
|---------------------------------------------------------|-----------------------------------------------------------------------------------------|-------------------|-------------------|--------------------|--------------------|-------------------|-------------------|-------------------|
|                                                         | 3 Mm.<br>0.12 In.                                                                       | 5 Mm.<br>0.20 In. | 8 Mm.<br>0.32 In. | 10 Mm.<br>0.39 In. | 20 Mm.<br>0.79 In. | 30 Mm.<br>1.2 In. | 40 Mm.<br>1.6 In. | 50 Mm.<br>2.0 In. |
| 0.0005 . . .                                            | 4                                                                                       | 12                | 22                | 35                 | 90                 | 170               | 280               | 410               |
| 0.001 . . .                                             | 7                                                                                       | 23                | 43                | 66                 | 160                | 300               | 480               | 690               |
| 0.002 . . .                                             | 15                                                                                      | 43                | 84                | 120                | 300                | 490               | 720               | 1,040             |
| 0.004 . . .                                             | 29                                                                                      | 83                | 160               | 230                | 520                | 790               | 1,070             | 1,360             |
| 0.01 . . .                                              | 72                                                                                      | 185               | 320               | 420                | 890                | 1,280             | 1,670             | 2,150             |
| 0.02 . . .                                              | 136                                                                                     | 320               | 500               | 630                | 1,280              | 1,800             | 2,340             | 3,030             |
| 0.05 . . .                                              | 300                                                                                     | 600               | 950               | 1,140              | 2,030              | 2,862             | 3,734             | 4,800             |
| 0.10 . . .                                              | 530                                                                                     | 1,000             | 1,400             | 1,650              | 2,850              | 4,044             | 5,280             | 6,800             |

By the aid of this table the underdrains, formed of layers of stones of different sizes, were proportioned as shown in the accompanying plan and sections. The larger stones were selected by hand, and if soiled were washed. The smaller sizes were selected by screening, and in this way all sand was removed. The stones of the two larger sizes were carefully placed at the open joints of the pipes to allow water to enter as freely as possible; the other layers were shovelled to place.

In extension of the old filter-gallery, to serve to conduct the water from the down-river underdrains to the gallery, a conduit was built with walls four inches thick of brick laid in Portland cement mortar, with the mortar left out of the end joints, which were a little more than an eighth of an inch wide. This conduit was two feet in diameter for a length of 105 feet, then 20 inches in diameter for a length of 120 feet, then 16 inches in diameter for a length of 65 feet, then 12 inches in diameter for a length of 30 feet, beyond which were ten-inch, eight-inch and six-inch glazed pipes, in lengths of 30 feet, laid as in the underdrains. This conduit was surrounded by the large stones 2 inches in diameter for a thickness of 4 inches, with layers of decreasing sizes around this, making a total thickness of about 8 inches.

Great care was taken to deposit the filtering sand so that the mass should be as homogeneous as possible. It was deposited in two layers. The first layer was covered with planks as fast as laid, upon which the loads were hauled, and these were dumped upon the planks near the edge, so that a part of the load ran over the bank and the other part was shovelled over. If the edge of the bank remained exposed to the wind and sun the coarser material would appear on the surface and run down. Such an edge was shovelled over before an addition was made.

The second layer was dumped upon the planks resting upon the lower layer and shovelled up to grade, and upon taking up the planks the lower layer was shovelled over to the depth of one foot and a half to remove the packing of the sand which was evident under the planks, sometimes to a depth of one foot.

It will be evident that watchful care was necessary in laying the underdraining stones to see that no bar of finer material crossed it in any direction. In fact, the success of the filter depended largely upon careful and conscientious superintendence of the construction of the underdrains and the bed. This was accomplished by Mr.

Charles C. Campbell, who had an intelligent appreciation of the essentials to success and most scrupulous care that the work should be done as directed.

Sand for the filter was obtained from a bank about seven-eighths of a mile away, where layers and pockets were found containing all kinds, from the very fine, almost impervious, sands to large gravel stones, and much unsuitable material had to be removed in selecting layers from which suitable sand could be obtained. By judicious selection, screening and mixing the two kinds of sand were obtained and wheeled to piles for loading. These piles were frequently tested by half filling with sand a cylinder six inches high and three inches in diameter, having a wire bottom. The sand was packed slightly and covered with a wire screen and the cylinder filled with water, and the time observed that it took the water to pass below the surface of the sand. Time limits for the two grades were determined at the laboratory, making correction for the temperature of the water, and the accuracy of these tests at the bank was determined by occasionally taking duplicate samples to the laboratory and making regular mechanical analyses by means of sieves.

The filter was completed, at a cost of about \$65,000, in the forenoon of Sept. 20, 1893, just about one year from the time of commencing, although there were four or five months when work was suspended; and in the afternoon of September 20 the inlet gate was opened and the water filled the open conduit along the base of the embankment, ran into the carriers, and gradually flowed over the one and one-third miles of level edge and entered the sand, disappearing in a short distance at first, but gradually as the sand was filled extending further from the carriers and filling the bottom of the twenty-six valleys, and then rising slowly up their sides and covering the ridges, forming a shallow pond of two and a half acres. Then the pumps were started, and when running at the rate of five million gallons in twenty-four hours we found that the difference in level between the water over the filter and in the pump-well was seventeen inches.

The water first coming through the filter contained an extremely fine dust in suspension, probably washed from the surfaces of the stones and underdrains. In the first ten days the chemical changes in the water were as follows: the albuminoid ammonia was reduced from 0.0168 to 0.0108 in parts per 100,000. The free ammonia was reduced from 0.0113 to 0.0072, and the nitrates were increased from 0.0120 to 0.0200 part. The color was reduced from 0.36 to 0.28

the scale for color. Since that time the average change has been in albuminoid ammonia from 0.0187 to 0.0104; free ammonia from 0.0067 to 0.0087, and the nitrates from 0.0140 to 0.0390 part, and the color reduced from 0.42 to 0.35. The hardness of the water has increased from 1.3 to 2.9.\* This change is probably partly temporary, due to absorption of lime from the conduit and carriers, but it is partly due to ground water, as it was the greatest when, in the latter part of February and early part of March, there was the greatest loss of head through the filter and consequently the greatest draft from the ground. At the same time there was an increase in the free ammonia of the filtered water, evidently due to the same cause; but this cause was an exceptional condition due to the surface of the bed not having been cleaned for three months, which will probably not occur again.

While the improvement of the water by the removal of the suspended matter and the burning up of the organic matter that was readily oxidizable was very satisfactory, the most important change and the real object of the construction of the filter was the removal of bacteria, and especially of those kinds of bacteria that are dangerous to health, known as disease germs.

The removal of bacteria is not merely a straining process; it is accomplished by making conditions unfavorable to the life of bacteria in the passage through the filter, which conditions grow with the proper use of the filter. In the first three days 75 per cent. of the number of bacteria applied came through the filter. In the next three days 30 per cent. came through, but in the first week in October only 4 per cent. came through, and in the next week 2 per cent.; that is, during the first three weeks' use the number of bacteria in the effluent rapidly decreased to 2 per cent. of the number applied, and from that time to the present,† excepting on two occasions when work on the filter or in the pump-well interfered with the results, the effluent from the filter has contained 1.7 per cent. of the number of bacteria contained in the river water, the filter having removed 98.3 per cent. of all of the bacteria in the water applied to it.\*

But the result given to the people is better than this. It appears that with the removal of those parts of the organic matter that are

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\* For results in detail of examinations of water from the Lawrence water works before and after filtration see pages 530-541, also 181-186.

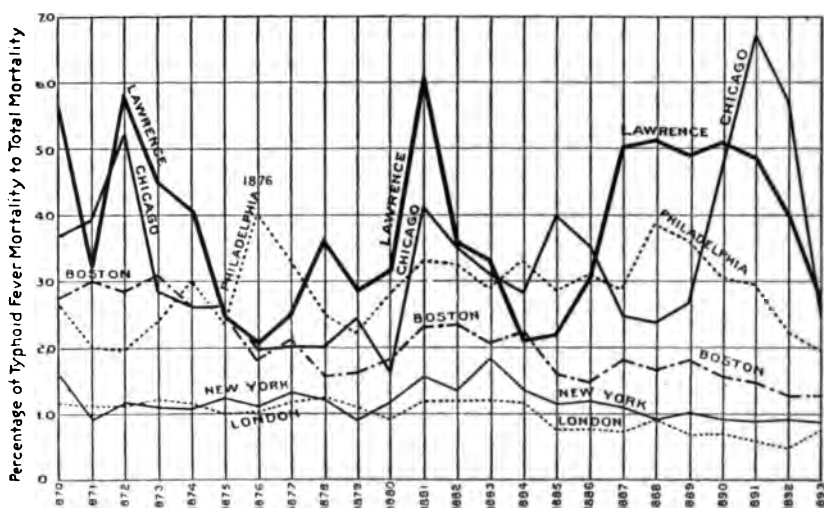
† June 1, 1894.

easily oxidized the food material of the bacteria has been removed, and as the water flows on through the reservoir and through the pipes the conditions of life are still unfavorable for the bacteria, and they go on decreasing, so that the numbers found at the outlet of the reservoir are but one and two-tenths per cent. of the numbers in the river water; and at the tap in the city hall the numbers of bacteria found are but nine-tenths of one per cent. of the numbers in the river water. More than ninety-nine per cent. of all of the bacteria of the river water have been removed.

The experiments of the State Board of Health go to show that with this result we can rely upon the complete extinction of all of the disease producing germs that may have been in the water.

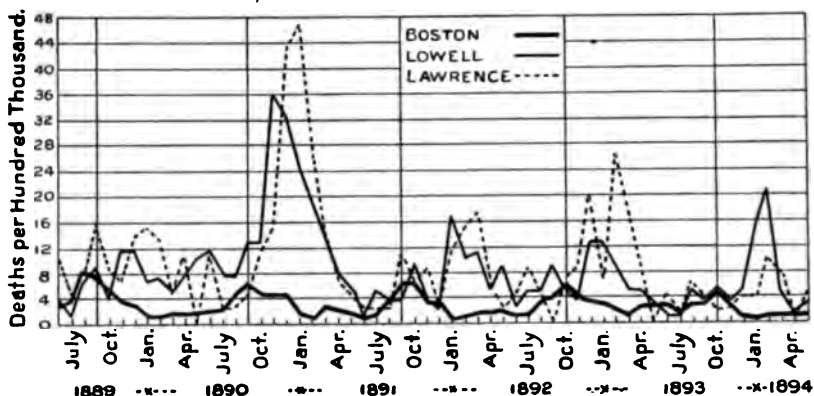
We have seen the effect of the filter upon the bacteria of the water applied to it; we will now seek the effect of the filter upon the inhabitants of Lawrence. It has been stated that the deaths from typhoid fever in Lawrence were about three times those of other cities in the State. Its relation to other cities from a broader field is shown by the following diagram, in which are given the percentage of mortality from typhoid fever to the total mortality in London, New York, Boston, Philadelphia, Chicago and Lawrence.

*Diagram showing Percentage of Typhoid Fever Mortality to Total Mortality in London, New York, Boston, Philadelphia, Chicago and Lawrence from 1870 to 1893.*



That the typhoid fever that has in the past affected Lawrence so seriously has come down the river year after year may be confirmed by the following diagram containing three broken lines. The heaviest

*Diagram showing Deaths per 100,000 Inhabitants in Boston, Lowell and Lawrence from June, 1889, to May, 1894.*



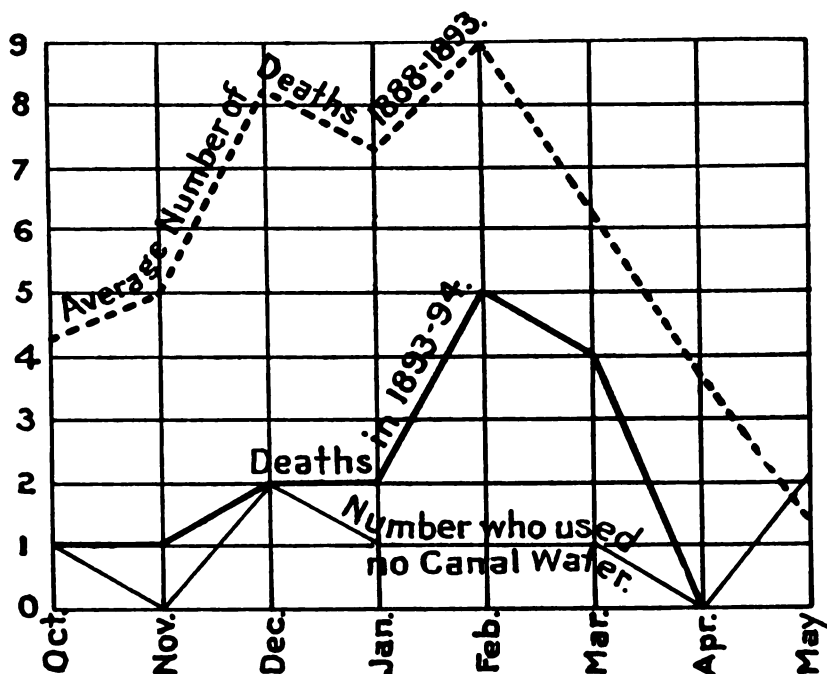
line indicates the number of deaths from typhoid fever in 100,000 inhabitants in the city of Boston in each month in the past five years. This line represents approximately the number of deaths from this disease in 100,000 inhabitants in the cities of the State and the months in which they occur. It will be seen that the months of greatest prevalence are September and October of each year. A vertical line has been drawn at such time of prevalence in each year at Boston, and this is nearly the time of its prevalence in our cities generally.

We see that in these months the disease prevailed to as great an extent in Lowell and Lawrence, but that following this period in about two months it prevails at Lowell to a much greater extent, and one or two months later it prevails to a still greater extent in Lawrence. This is the case year after year until during the past winter, when in February and March there was an increase in Lawrence following that at Lowell, but instead of being in greater numbers, as in former years, it was to only about half as many per 100,000, and the cause of this increase will now be considered.

In the following diagram the average number of deaths from typhoid fever at Lawrence for each month from October to May, in the preceding five years, are given by the heavy dotted line; and

the number during the past eight months are given by the heavy full line.

*Typhoid Fever in Lawrence.*



The total number for the eight months in past years has been forty-three, and in the present year seventeen, making a saving of twenty-six. Of the seventeen who died nine were operatives in the mills, each of whom was known to have drunk unfiltered canal water, which is used in the factories at the sinks for washing.

The finer full line shows the number of those who died month after month who are not known to have used the poisoned canal water. The whole number in the eight months is eight.

It is evident from the previous diagram that the numbers above the fine full line, here, follow after those at Lowell in the usual time, and were undoubtedly caused by the sickness at Lowell; but we have satisfactory reason to conclude that the disease was not propagated through the filter but that the germs were conveyed directly into the canals and to those who drank of the unfiltered canal water. Among the operatives of one of the large corporations not using the



canal water there was not a case of typhoid fever during this period. Warnings have been placed in the mills where canal water is used to prevent the operatives from drinking it.

We find, then, that the mortality from typhoid fever has, during the use of the filter, been reduced to 40 per cent. of the former mortality, and that the cases forming nearly one-half of this 40 per cent. were undoubtedly due to the continued use of unfiltered river water drawn from the canals.

The effect of the filter in preventing the communication of diarrhœal and other diseases carried by water can be given after the season of the year when these diseases prevail. We can say further at present that the physicians have very generally reported a marked improvement in the health of the people since the filter came into use.

The study of this problem and its solution have established with more of certainty than ever before three important points in sanitary science : —

1. The insufficiency of the self-purification of streams.
2. The ready conveyance of typhoid fever down a stream by sewage-polluted drinking water.
3. The practicability of protecting a community against an infected drinking water supply by natural sand filtration.

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SEWAGE PURIFICATION  
OF  
CITIES AND TOWNS IN MASSACHUSETTS.

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## SEWAGE PURIFICATION OF CITIES AND TOWNS IN MASSACHUSETTS.

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The last annual report (1892) contained a paper upon the "Sewage Disposal of Cities and Towns in Massachusetts by Intermittent Filtration," which was accompanied by chemical analyses of the sewage and effluent from the works of the three places described, viz. : Framingham, Marlborough and Gardner. Owing to the time required for the publication of that report it was feasible to include in it analyses made up to the end of July, 1893. In the present paper results from sewage disposal works at several additional places are given, and analyses of sewage and effluent from the three places mentioned above are included only from the first of August to the end of the year. A short description of each of the systems examined is given in the following pages, and to assist the reader in understanding the conditions at the various places some of the statements made last year are repeated.

The first plant for the disposal of town sewage by intermittent filtration in Massachusetts was constructed at Lenox in 1876. A system for the disposal of the sewage of a portion of the town of Amherst, partly by filtration but chiefly by irrigation, was constructed about 1881, and a small system for the disposal of sewage by intermittent filtration was introduced at Medfield in 1886. Since the last date the towns of Framingham and Gardner and the city of Marlborough have constructed and are now operating works for the disposal of sewage by intermittent filtration, and a new disposal field has been constructed and is in use at Lenox. The city of Brockton (population in 1890, 27,294,) is at present constructing works of this kind, which will be operated in 1894. There are, also, several large institutions which dispose of their sewage by intermittent filtration. The sewage of the city of Worcester is treated by chemical precipitation, as described on page 341 of this report.

In order to learn the results obtained by the systems of sewage disposal in the various places, the State Board of Health has caused many analyses of the sewage and effluent from the filter-beds at Framingham, Gardner and Marlborough to be made, and has also made one or more chemical examinations of the sewage and effluent from the sewage disposal works at Amherst, Lenox, Medfield, Westborough and Wellesley College. The results of these analyses are given in connection with a description of the works in the pages which follow. Analyses made by the chemists at Worcester, showing the results obtained at the chemical precipitation works there, have already been given on page 345.

#### SEWAGE DISPOSAL AT AMHERST.

The population of the town in 1890 was 4,512. Sewerage facilities have been provided only for portions of the main village, and the sewage is disposed of by two systems.

The first system, begun in 1881 and subsequently extended, collects the sewage from about 1,000 inhabitants. The sewage flows to a settling tank about a mile south-east of the village and thence through a pipe 520 feet long into Fort River.

By the second system, since 1886, the sewage of a portion of the thickly populated part of the town north of the town hall has been applied, after settling in a tank, to a field having an area of about three acres and a slight slope, located about half a mile north of the village. It is said that there are about 300 people connected with this system, and storm-water is excluded from the sewers. The sewage is conducted by a ten-inch pipe to a settling tank located on the upper side of the disposal field. The tank is about 4 feet deep and holds about 500 gallons. The outlet pipe is arranged to avoid drawing the scum from the surface of the tank, and discharges into a long ditch running along the upper side of the field, from which the sewage is discharged through openings in its sides. The place of discharge is changed from time to time by blocking up the existing opening and making a new one. The sludge from the settling tank is removed at intervals and composted. Analyses of the sewage before and after settling in the tank are given below. There is no opportunity to obtain a sample of the effluent from this field, as the sewage sinks into the ground and does not reappear in such a way that a sample can be collected.

*Chemical Examination of Sewage from Amherst.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                 |        | RESIDUE ON EVAPORATION. |            |            |                   |            |            |
|---------|---------------------|-------------|-----------------|--------|-------------------------|------------|------------|-------------------|------------|------------|
|         |                     | Turbidity.  | Sediment.       | Color. | TOTAL RESIDUE.          |            |            | LOSS ON IGNITION. |            |            |
|         |                     |             |                 |        | Total.                  | Dissolved. | Suspended. | Total.            | Dissolved. | Suspended. |
| 11,385  | 1893.<br>Nov. 25,   | Decided.    | Heavy,<br>gray. | 1.20   | 104.50                  | 27.50      | 77.00      | 84.50             | 11.80      | 72.70      |
| 11,386  | Nov. 25,            | Decided.    | Heavy,<br>gray. | 1.50   | 39.90                   | 27.40      | 12.50      | 21.50             | 11.30      | 10.20      |

*Chemical Examination of Sewage from Amherst—Concluded.*

[Parts per 100,000.]

| AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | OXYGEN CONSUMED.* |           | IRON.       |           | Hardness. |
|----------|-------------|------------|------------|-----------|-------------|-----------|-------------------|-----------|-------------|-----------|-----------|
| Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. | Unfiltered.       | Filtered. | Unfiltered. | Filtered. |           |
|          | Total.      | Dissolved. | Suspended. |           |             |           |                   |           |             |           |           |
| 1.9200   | .6300       | .4080      | .2240      | 3.44      | .0000       | .0000     | 6.8800            | 0.7740    | .0750       | .0500     | 6.7       |
| 1.2000   | .3420       | .2480      | .0940      | 3.43      | .0000       | .0000     | 6.1490            | 3.9130    | .0800       | .0600     | 4.9       |

Odor, offensive. — The first sample was collected from the main sewer of the northerly system as it discharges into the settling tank. The last sample, from the pipe which conveys sewage from the settling tank to a ditch on the sewage disposal area.

\* The determinations of Oxygen Consumed, given in this paper, were made after boiling five minutes.

## SEWAGE DISPOSAL AT THE NORFOLK COUNTY JAIL, DEDHAM.

*Chemical Examination of Water from the Brook which flows from Fisher's Ice Pond above and below the Sewage Disposal Area of the Norfolk County Jail.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                  |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.        | Color. | Total.                  | Loss on ignition. | Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                  |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 9835    | 1893.<br>Jan. 1     | Slight.     | Slight,<br>dark. | 0.30   | 4.80                    | 1.70              | .0018    | .0188       | .0130      | .0058      | .56       | .0030       | .0001     | .3723            | 1.8       |
| 9836    | Jan. 1              | Slight.     | Slight,<br>dark. | 0.30   | 4.70                    | 1.30              | .0022    | .0116       | .0082      | .0034      | .58       | .0100       | .0001     | .3650            | 2.1       |

Iron, in each sample, .0080. Odor, distinctly vegetable, disappearing on heating. — The first sample was collected about 500 feet above the sewage disposal area and the last a very short distance below it. Sewage had been discharged upon the area about 6 hours before the samples were collected.

It is evident from the analyses that no sewage effluent was present in the sample collected below the disposal area.

*Microscopical Examination.*

No. 9835. Diatomaceæ, *Asterionella*, 2; *Meridion*, 8; *Synedra*, 2; *Tabellaria*, 1. Fungi, *Crenothrix*, 3. Miscellaneous, *Zoëglæa*, 48. Total, 64.

No. 9836. Diatomaceæ, *Meridion*, 2; *Synedra*, 1. Fungi, *Crenothrix*, 3. Miscellaneous, *Zoëglæa*, 28. Total, 34.

## SEWAGE DISPOSAL AT FRAMINGHAM.

The town of Framingham (population in 1890, 9,239,) contains three villages, of which South Framingham is by far the most populous, and up to the present time is the only village sewered.

The sewerage system was put in operation near the end of the year 1889, and at the end of the year 1893, 610 dwelling-houses and 41 business blocks, stores, factories, etc., were connected with the sewers. In addition to this the sewage of the women's prison (population about 350), located in the town of Sherborn, just beyond the Framingham line, is taken care of by this system.

Storm-water is excluded from the sewers, and a continuous system of underdrains was laid beneath the principal sewers to collect and carry off the ground water. The amount of sewage flowing during a season of high rainfall, however, is fully three times the ordinary flow. The main underdrain discharges by gravity into a brook, and the character of the water discharged by it can be seen by reference

to a table of analyses on page 153 of this volume.\* The average amount of sewage pumped and purified in 1893 was 218,000 gallons per day.

The sewage, after collection in a pair of receiving reservoirs having a total capacity of 431,000 gallons, is pumped during the day-time to the filtration area, which is located about two and one-half miles north-east of the village of South Framingham. This area, a more detailed description of which, accompanied by a plan, may be found in the annual report of the Board for 1892, page 560, covers about seventy acres, much of which is quite level and at an elevation of about 20 feet above Bannister Brook. An area of about twelve acres has been specially prepared for filtration by dividing it into ten beds of convenient size, removing most of the loam, which was used in the construction of embankments between the beds, and by levelling the surface. Six of the beds are underdrained to a limited extent.

In 1893 about nine acres of the prepared beds were planted with field corn (maize), and the remainder with squashes, beans, potatoes and cabbages. The crops were very satisfactory, especially the field corn, and received only ordinary attention. The preparation of additional filter-beds is under way in order to increase the area to be devoted to farming purposes. The present area, however, is amply sufficient for the disposal of the sewage.

A reasonable objection has often been made to the cultivation of crops in connection with intermittent filtration, where the area is small, owing to the danger that, in order to avoid injuring the crops, the flow of sewage at certain seasons of the year will either be concentrated on a small portion of the area or allowed to escape unpurified. In the case of Framingham, however, the cultivation of crops has had a favorable effect upon the purification of the sewage by inducing the preparation of additional filter-beds, by loosening the soil by ploughing and other disturbances of the surface incident to cultivation, and by the removal by the crops of matters brought to the beds in the sewage.

The surfaces of nine of the filter-beds were left during the winter of 1893-94 in hills and furrows, and without disturbance, after the crops

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\* Analyses of water from this underdrain are also given in the annual reports of the Board for 1890, 1891 and 1892, pages 149, 131 and 126, respectively. The first sample analyzed was collected before any sewage had been admitted to the sewers, and the character of the water has not changed materially since sewage was admitted.



had been removed from them. The remaining bed was ploughed and wide furrows made, about 6 feet apart, at right angles to the carriers along the side of the bed from which the sewage is applied. It was found that this bed gave the most satisfactory results, particularly when there was much snow on the ground. It is also to be noted that the beds where the surface is left in hills and furrows are much more efficient in winter than beds with level surfaces.

The quality of the sewage and of the effluent from several different places may be seen by the tables of analyses on the following pages. The sewage is ordinary town sewage, discolored and somewhat modified in character at times by a considerable amount of spent dyes discharged into the sewers from the straw goods factories in the town.

With regard to the purification effected at Framingham it may be said that the conditions for filtration are very favorable, owing to the large area of land in use in proportion to the amount of sewage treated, the porosity of the material, which has an effective size of 0.32 to 0.42 millimeter, and the depth to ground water. Another favorable condition is the high temperature of the sewage in winter (48° to 50° F.) due chiefly to the fact that the water supply of the

*Chemical Examination of*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.     |               |        | RESIDUE ON EVAPORATION. |            |            |                   |            |            |
|---------|---------------------|-----------------|---------------|--------|-------------------------|------------|------------|-------------------|------------|------------|
|         |                     | Turbidity.      | Sediment.     | Color. | TOTAL RESIDUE.          |            |            | LOSS ON IGNITION. |            |            |
|         |                     |                 |               |        | Total.                  | Dissolved. | Suspended. | Total.            | Dissolved. | Suspended. |
|         | <b>1893.</b>        |                 |               |        |                         |            |            |                   |            |            |
| 1       | 10807 Aug. 15       | Thick, opaque.  | Cons., dark.  | 0.40   | 42.50                   | 33.20      | 9.30       | 20.40             | 13.10      | 7.30       |
| 2       | 10924 Aug. 30       | Decided, milky. | Heavy, dark.  | 0.60   | 49.60                   | 29.30      | 20.30      | 25.00             | 9.30       | 15.70      |
| 3       | 11006 Sept. 11      | Decided, thick. | Cons., dark.  | -      | 31.60                   | 28.20      | 3.40       | 12.00             | 10.00      | 2.00       |
| 4       | 11081 Sept. 25      | Decided.        | Heavy, dark.  | -      | 36.80                   | 31.20      | 5.60       | 12.80             | 12.00      | 0.80       |
| 5       | 11184 Oct. 12       | Thick.          | Cons., gray.  | 0.70   | 46.80                   | 40.60      | 6.20       | 21.20             | 15.60      | 5.60       |
| 6       | 11283 Nov. 1        | Decided.        | Cons., black. | -      | 108.00                  | 46.00      | 62.00      | 68.20             | 14.00      | 54.20      |
| 7       | 11322 Nov. 10       | Decided.        | Cons., gray.  | 0.70   | 33.40                   | 29.40      | 4.00       | 12.80             | 10.40      | 2.40       |
| 8       | 11414 Nov. 29       | Thick, black.   | Heavy, black. | 1.00   | 65.00                   | 46.20      | 18.80      | 27.40             | 12.80      | 14.60      |
| 9       | 11491 Dec. 13       | Thick, dark.    | Heavy, dark.  | 0.60   | 40.60                   | 33.20      | 7.40       | 15.20             | 8.20       | 7.00       |
| 10      | Av.*                |                 |               | 0.58   | 57.90                   | 33.80      | 24.09      | 30.37             | 10.95      | 19.43      |

\* This average is for the whole year 1893, and includes the results of analyses made during the earlier part of the year and printed in the preceding annual report.

town is taken from the ground and has a winter temperature of about 49°.

Only a small portion of the effluent is collected by the underdrains beneath the beds, and of this quantity all or nearly all again enters the ground and receives a second filtration before it reaches the brook, while most of the effluent passes for a long distance through the ground and appears in the form of springs at the edge of the low land near the brook. The existence of lateral filtration to such a marked degree is believed to be a very important feature of the Framingham filter-beds.

The average degree of purification of the applied sewage in 1893, as indicated by the albuminoid ammonia in the analyses, is as follows:—

|                                        | Per Cent. of<br>Organic Matter<br>Removed<br>(Albuminoid<br>Ammonia). |
|----------------------------------------|-----------------------------------------------------------------------|
| Effluent at east underdrain, . . . . . | 97.6                                                                  |
| “ at west underdrain, . . . . .        | 98.0                                                                  |
| “ at spring, . . . . .                 | 99.6                                                                  |

*Sewage from Framingham.*

[Parts per 100,000.]

| AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | OXYGEN CONSUMED. |           | IRON.       |           | Hardness. |    |
|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|-------------|-----------|-----------|----|
| Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. | Unfiltered.      | Filtered. | Unfiltered. | Filtered. |           |    |
|          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |             |           |           |    |
| 2.0000   | .3400       | .1840      | .1760      | 4.86      | .0000       | .0000     | 4.0922           | 2.6860    | .0900       | .0600     | -         | 1  |
| 1.6000   | .3700       | .1840      | .1860      | 5.20      | .0100       | .0000     | 5.0660           | 2.2910    | .0850       | .0270     | -         | 2  |
| 2.7200   | .2000       | .1140      | .0860      | 5.40      | .0000       | .0000     | 3.1200           | 2.8080    | .0400       | .0400     | 5.1       | 3  |
| 2.8800   | .3280       | .2140      | .1140      | 6.80      | .0050       | .0000     | 1.5580           | 1.1480    | .2400       | .1240     | 5.9       | 4  |
| 1.6000   | .2620       | .1900      | .0720      | 8.00      | .0050       | .0000     | 3.6855           | 2.9160    | .1160       | .1000     | 5.1       | 5  |
| 2.2400   | .4380       | .2240      | .2140      | 6.75      | .0000       | .0000     | 6.2800           | 3.1200    | .1200       | .0520     | 5.1       | 6  |
| 1.9840   | .3940       | .3100      | .0840      | 4.70      | .0050       | .0000     | 4.3575           | 2.1165    | .0900       | .0520     | 5.3       | 7  |
| 4.0000   | .5840       | .3900      | .1940      | 5.80      | .0050       | .0000     | 21.3150          | 2.9580    | .3800       | .2300     | 4.7       | 8  |
| 2.0800   | .3440       | .2700      | .0740      | 5.39      | .0000       | .0250     | 4.1440           | 3.0640    | .0700       | .0560     | 6.1       | 9  |
| 2.0283   | .4008       | .2152      | .1854      | 5.22      | .0135       | .0115     | -                | -         | .1290       | .0720     | 5.8       | 10 |

Odor, offensive. — The sewage was collected as it flowed out upon the filter-beds.

*Chemical Examination of Effluent from the East*

[Parts per 100,000.]

|    | Number. | Date of Collection. | APPEARANCE.      |                |        | ODOR.                    |                          |
|----|---------|---------------------|------------------|----------------|--------|--------------------------|--------------------------|
|    |         |                     | Turbidity.       | Sediment.      | Color. | Cold.                    | Hot.                     |
| 1  | 10809   | 1893.<br>Aug. 15    | Slight.          | Very slight.   | 0.02   | Distinctly disagreeable. | Distinctly disagreeable. |
| 2  | 10926   | Aug. 30             | Distinct.        | Slight, white. | 0.02   | Distinctly musty.        | Very faint or none.      |
| 3  | 11007   | Sept. 11            | None.            | Slight.        | 0.00   | None.                    | None                     |
| 4  | 11083   | Sept. 25            | Very slight.     | Cons.          | 0.00   | Distinctly musty.        | Very faintly musty.      |
| 5  | 11186   | Oct. 12             | Distinct, milky. | Slight.        | 0.05   | Offensive.               | Decidedly musty.         |
| 6  | 11285   | Nov. 1              | Distinct, milky. | Slight.        | 0.05   | Decidedly musty.         | Decidedly musty.         |
| 7  | 11324   | Nov. 10             | Very slight.     | Slight, white. | 0.00   | Very faintly musty.      | Distinctly musty.        |
| 8  | 11416   | Nov. 29             | Very slight.     | Very slight.   | 0.02   | Very faintly musty.      | Decidedly musty.         |
| 9  | 11493   | Dec. 13             | Slight.          | Very slight.   | 0.00   | None.                    | Very faint or none.      |
| 10 | Av.*    | .....               | .....            | .....          | 0.03   | .....                    | .....                    |

\* The average given here includes the results of analyses made during the earlier part of the year and printed in the preceding annual report. No analyses were made in January or February.

*Chemical Examination of Effluent from the West*

[Parts per 100,000.]

|    | Number. | Date of Collection. | APPEARANCE.  |                          |        | ODOR.               |                      |
|----|---------|---------------------|--------------|--------------------------|--------|---------------------|----------------------|
|    |         |                     | Turbidity.   | Sediment.                | Color. | Cold.               | Hot.                 |
| 1  | 10808   | 1893.*<br>Aug. 15   | Very slight. | Slight.                  | 0.03   | None.               | Faintly musty.       |
| 2  | 10925   | Aug. 30             | Very slight. | Very slight.             | 0.02   | None.               | Very faintly mouldy. |
| 3  | 11008   | Sept. 11            | Very slight. | Slight.                  | 0.00   | None.               | Distinct.            |
| 4  | 11082   | Sept. 25            | None.        | Considerable, yellowish. | 0.02   | Faintly musty.      | Distinctly sweetish. |
| 5  | 11185   | Oct. 12             | None.        | Very slight.             | 0.03   | None.               | Faintly musty.       |
| 6  | 11284   | Nov. 1              | None.        | Slight.                  | 0.02   | None.               | Distinctly musty.    |
| 7  | 11323   | Nov. 10             | Very slight. | Slight, yellowish.       | 0.00   | Very faint or none. | Distinctly musty.    |
| 8  | 11415   | Nov. 29             | None.        | Very slight.             | 0.00   | None.               | Distinctly musty.    |
| 9  | 11492   | Dec. 13             | None.        | Slight, earthy.          | 0.00   | None.               | Very faint or none.  |
| 10 | Av.*    | .....               | .....        | .....                    | 0.04   | .....               | .....                |

\* This average is for the whole year 1893, and includes the results of analyses made during the earlier part of the year and printed in the preceding annual report.

*Underdrain at the Framingham Filter-beds.*

[Parts per 100,000.]

| Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |    |
|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|----|
|                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |    |
| 35.50                   | .0720    | .0060       | 4.89      | 2.4000      | .0120     | .1501            | 6.2       | .0100 | 1  |
| 27.50                   | .0640    | .0040       | 3.80      | 1.5000      | .0080     | .1659            | 5.4       | .0120 | 2  |
| 16.70                   | .0280    | .0060       | 2.58      | 1.3000      | .0070     | .1716            | 3.9       | .0400 | 3  |
| 19.10                   | .0560    | .0060       | 3.89      | 1.0000      | .0010     | .0738            | 3.6       | .0050 | 4  |
| 29.70                   | .1490    | .0270       | 5.45      | 1.2000      | .0090     | .3442            | 8.1       | .0200 | 5  |
| 28.40                   | .1320    | .0110       | 5.01      | 1.0000      | .0090     | .3080            | 7.1       | .0120 | 6  |
| 29.10                   | .0400    | .0040       | 5.22      | 1.4000      | .0060     | .1826            | 6.4       | .0040 | 7  |
| 26.30                   | .0600    | .0040       | 3.80      | 1.7000      | .0120     | .1914            | 6.0       | .0000 | 8  |
| 28.80                   | .1120    | .0040       | 4.07      | 1.8000      | .0050     | .1504            | 6.0       | .0200 | 9  |
| 24.70                   | .1786    | .0095       | 3.85      | 1.2202      | .0074     | -                | 5.6       | .0114 | 10 |

The samples were collected from the underdrain at its outlet.

*Underdrain at the Framingham Filter-beds.*

[Parts per 100,000.]

| Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |    |
|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|----|
|                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |    |
| 29.80                   | .0480    | .0030       | 4.00      | 1.6000      | .0100     | .1422            | 7.6       | .0080 | 1  |
| 27.10                   | .0520    | .0050       | 4.17      | 1.6000      | .0040     | .1106            | 6.1       | .0150 | 2  |
| 28.70                   | .0320    | .0030       | 3.98      | 1.7000      | .0030     | .1014            | 7.3       | .0100 | 3  |
| 28.00                   | .0600    | .0150       | 3.79      | 1.4000      | .0050     | .0943            | 5.9       | .0100 | 4  |
| 25.60                   | .0160    | .0030       | 3.62      | 1.8000      | .0010     | .1417            | 5.1       | .0060 | 5  |
| 24.90                   | .0280    | .0050       | 3.58      | 1.0500      | .0060     | .1320            | 5.1       | .0040 | 6  |
| 24.70                   | .0320    | .0040       | 3.97      | 1.2000      | .0040     | .1618            | 5.4       | .0040 | 7  |
| 26.00                   | .0400    | .0040       | 3.46      | 1.1000      | .0050     | .1696            | 5.1       | .0180 | 8  |
| 26.10                   | .0560    | .0040       | 3.63      | 1.6000      | .0030     | .1584            | 5.6       | .0140 | 9  |
| 23.55                   | .1071    | .0080       | 3.64      | 1.0360      | .0045     | -                | 5.3       | .0098 | 10 |

The samples were collected from the underdrain at its outlet.

*Chemical Examination of Water from a Spring near Bannister*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |              |        | ODOR. |       |
|---------|---------------------|-------------|--------------|--------|-------|-------|
|         |                     | Turbidity.  | Sediment.    | Color. | Cold. | Hot.  |
| 1       | 10810 Aug. 15       | None.       | None.        | 0.0    | None. | None. |
| 2       | 10927 Aug. 30       | None.       | Very slight. | 0.0    | None. | None. |
| 3       | 11009 Sept. 11      | None.       | None.        | 0.0    | None. | None. |
| 4       | 11084 Sept. 25      | None.       | Slight.      | 0.0    | None. | None. |
| 5       | 11187 Oct. 12       | None.       | Very slight. | 0.0    | None. | None. |
| 6       | 11286 Nov. 1        | None.       | None.        | 0.0    | None. | None. |
| 7       | 11325 Nov. 10       | None.       | None.        | 0.0    | None. | None. |
| 8       | 11417 Nov. 29       | None.       | None.        | 0.0    | None. | None. |
| 9       | 11404 Dec. 13       | None.       | None.        | 0.0    | None. | None. |
| 10      | Av.*                | .....       | .....        | 0.0    | ..... | ..... |

\* The average given here includes the results of analyses made during the earlier part of

*Chemical Examination of Water from Bannister Brook below the Framingham Filter-beds.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |              |        | RESIDUE ON EVAPORATION. |                   | AMMONIA.    |        |            |            | NITROGEN AS |           | Oxygen Consumed. | Hardness. |           |
|---------|---------------------|-------------------|--------------|--------|-------------------------|-------------------|-------------|--------|------------|------------|-------------|-----------|------------------|-----------|-----------|
|         |                     | Turbidity.        | Sediment.    | Color. | Total.                  | Loss on Ignition. | ALBUMINOID. |        |            |            | Chlorine.   | Nitrates. |                  |           | Nitrites. |
|         |                     |                   |              |        |                         |                   | Free.       | Total. | Dissolved. | Suspended. |             |           |                  |           |           |
| 10001   | 1893.<br>Feb. 13    | Slight.           | Cons. brown. | 1.80   | 5.90                    | 3.05              | .0040       | .0294  | .0252      | .0042      | 0.35        | .0250     | .0001            | 1.4819    | 1.7       |
| 11010   | Sept. 11            | Distinct.         | Slight.      | 0.70   | 8.75                    | 3.05              | .0012       | .0160  | .0122      | .0038      | 1.38        | .1200     | .0002            | 0.5148    | 2.8       |
| 11065   | Sept. 25            | Slight.           | Slight.      | 0.62   | 8.50                    | 1.90              | .0014       | .0162  | .0128      | .0034      | 1.60        | .1000     | .0003            | 0.4182    | 2.5       |
| 11188   | Oct. 12             | Slight, clayey.   | V. slight.   | 0.55   | 7.75                    | 2.20              | .0030       | .0156  | .0122      | .0034      | 1.16        | .0280     | .0010            | 0.4090    | 3.5       |
| 11287   | Nov. 1              | Slight.           | Slight.      | 1.50   | 8.25                    | 2.85              | .0026       | .0282  | .0262      | .0020      | 0.96        | .0230     | .0004            | 1.1480    | 2.5       |
| 11326   | Nov. 10             | Distinct, clayey. | V. slight.   | 1.40   | 7.35                    | 2.65              | .0026       | .0270  | .0250      | .0020      | 0.97        | .0450     | .0003            | 1.1495    | 2.5       |
| 11418   | Nov. 29             | Slight.           | Slight.      | 0.95   | 6.55                    | 2.60              | .0018       | .0450  | .0264      | .0186      | 0.86        | .0380     | .0001            | 1.0831    | 2.5       |
| Av.     | .....               | .....             | .....        | 1.15   | 7.37                    | 2.67              | .0026       | .0259  | .0207      | .0052      | 0.96        | .0505     | .0003            | 0.9608    | 2.5       |

Odor, distinctly vegetable, rarely mouldy. On heating the odor is generally stronger and frequently mouldy or unpleasant. — The samples were collected from the brook at the first road crossing below the sewage field.

*Brook, which receives Effluent from the Framingham Filter-beds.*

[Parts per 100,000.]

| Residue on<br>Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen<br>Consumed. | Hardness. | Iron. |    |
|----------------------------|----------|-------------|-----------|-------------|-----------|---------------------|-----------|-------|----|
|                            | Frec.    | Albuminoid. |           | Nitrates.   | Nitrites. |                     |           |       |    |
| 14.30                      | .0000    | .0010       | 2.77      | .4500       | .0000     | .0276               | 3.4       | .0050 | 1  |
| 14.10                      | .0006    | .0022       | 2.80      | .7000       | .0000     | .0553               | 2.9       | .0000 | 2  |
| 13.50                      | .0000    | .0000       | 2.66      | .7000       | .0000     | .0078               | 4.2       | .0000 | 3  |
| 13.45                      | .0000    | .0016       | 2.72      | .5000       | .0000     | .0410               | 3.6       | .0025 | 4  |
| 14.70                      | .0004    | .0004       | 2.81      | .5250       | .0000     | .0445               | 3.9       | .0040 | 5  |
| 15.50                      | .0000    | .0000       | 2.93      | .5500       | .0001     | .0400               | 4.4       | .0000 | 6  |
| 14.25                      | .0000    | .0008       | 3.17      | .5000       | .0000     | .0996               | 4.0       | .0000 | 7  |
| 14.30                      | .0000    | .0012       | 2.54      | .6000       | .0000     | .0870               | 3.9       | .0000 | 8  |
| 14.00                      | .0000    | .0010       | 2.63      | .5800       | .0000     | .0432               | 4.6       | .0050 | 9  |
| 13.45                      | .0001    | .0014       | 2.76      | .5095       | .0000     | -                   | 3.6       | .0030 | 10 |

the year and printed in the preceding annual report. No analyses were made in January.

### SEWAGE DISPOSAL AT GARDNER.

The Gardner sewerage system was put in operation about Aug. 1, 1891. At the end of 1893 there were 161 connections with the sewers, 120 of which were from dwelling-houses and the remainder from factories, business blocks, hotels and public buildings. The population of the town in 1890 was 8,424. With the exception of roof-water, used for flushing purposes, from a limited number of buildings at the upper ends of the sewers, surface water is excluded. The quantity of sewage is not definitely known, but it is probably not far from 200,000 gallons per day in dry weather.

The tract purchased by the town for the disposal of the sewage contains 16.9 acres. Much of the material upon this tract was found to be too fine for the filtration of sewage, and, as a result, the filter-beds are almost wholly artificial, being formed of the porous sand and gravel from a ridge upon this tract. There are twelve thoroughly underdrained filter-beds for the disposal of sewage, having a total area of 1.39 acres, two supplementary beds which are less porous and not underdrained, having a total area of 0.37 acre, and two other small underdrained beds, containing together 0.14 acre. One of these

small beds is used to receive the sludge from the sludge tank, and the other to receive the discharge from a blow-off located at the lowest point in the pipe leading from the town, which, for the last 1,050 feet of its length where it crosses the valley of Pond Brook, is an inverted siphon. This bed was not used in 1893, however, because it has been found that if clogging occurs the sewage backs up in the pipe until sufficient head is obtained to remove the obstruction. The material of the filter-beds has an effective size of 0.10 to 0.24 millimeter, which is somewhat coarser than at Marlborough but much finer than at Framingham. The underdrains beneath the beds are generally twenty feet apart and at a depth of from four to five feet below the surface of the beds.

The sewage, when it reaches the disposal area, first passes through duplicate separating tanks having a total capacity of about 10,000 gallons, and overflows through wooden troughs upon the disposal area, as described in the annual report of the Board for 1892, page 580.

It has been the custom, except during the winter months, to apply sewage to one-half of the beds one day and the other half the next, and once in ten days or two weeks to remove one-eighth to one-quarter inch of scum and clogged sand, and afterward to rake to a depth of about 1.5 inches to loosen the material. Below this depth the material is compact to a depth of several inches.

*Chemical Examination of*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |               |        | RESIDUE ON EVAPORATION. |            |            |                   |            |            |
|---------|---------------------|--------------------|---------------|--------|-------------------------|------------|------------|-------------------|------------|------------|
|         |                     | Turbidity.         | Sediment.     | Color. | TOTAL RESIDUE.          |            |            | LOSS ON IGNITION. |            |            |
|         |                     |                    |               |        | Total.                  | Dissolved. | Suspended. | Total.            | Dissolved. | Suspended. |
| 1       | 1893.<br>Aug. 14    | Thick.             | Heavy, dark.  | 0.90   | 64.50                   | 45.30      | 19.20      | 32.20             | 17.30      | 14.90      |
| 2       | 10920<br>Aug. 30    | Decided,<br>milky. | Cons.         | 0.50   | 28.40                   | 19.10      | 9.30       | 15.40             | 7.40       | 8.00       |
| 3       | 11002<br>Sept. 11   | Decided,<br>thick. | Heavy.        | 0.50   | 60.10                   | 25.80      | 34.30      | 41.10             | 13.60      | 27.50      |
| 4       | 11097<br>Sept. 27   | Decided.           | Heavy, gray.  | 0.70   | 32.80                   | 21.80      | 11.00      | 18.00             | 10.00      | 8.00       |
| 5       | 11180<br>Oct. 12    | Decided.           | Heavy, gray.  | 1.20   | 48.40                   | 25.40      | 21.00      | 29.20             | 11.60      | 17.60      |
| 6       | 11288<br>Oct. 30    | Decided.           | Heavy, gray.  | 1.20   | 36.60                   | 24.00      | 12.60      | 19.00             | 9.00       | 10.00      |
| 7       | 11334<br>Nov. 14    | Decided.           | Heavy, gray.  | 0.60   | 29.20                   | 18.40      | 10.80      | 13.60             | 7.00       | 6.60       |
| 8       | 11410<br>Nov. 28    | Decided.           | Heavy, gray.  | 0.60   | 35.50                   | 20.40      | 15.40      | 16.40             | 8.00       | 8.40       |
| 9       | 11487<br>Dec. 13    | Very thick.        | Heavy.        | 0.70   | 43.20                   | 20.80      | 22.40      | 30.00             | 10.20      | 19.80      |
| 10      | 11556<br>Dec. 27    | Thick.             | Cons., white. | 0.60   | 28.80                   | 23.20      | 5.60       | 17.50             | 12.20      | 5.60       |
| 11      | Av.*                | .....              | .....         | 0.61   | 33.35                   | 20.90      | 12.45      | 19.01             | 9.23       | 9.79       |

\* This average is for the whole year 1893, and includes the results of analyses made during the earlier part of the year and printed in the preceding annual report.

The results obtained at Gardner have been satisfactory in the summer, but, as stated in the last annual report, in order to obtain these results it has been necessary to attend carefully to the distribution of the sewage upon the different beds, and to remove at frequent intervals the scum which forms upon them. During cold weather when the removal of this scum is prevented by snow and ice upon the beds, it has not been found practicable to filter the sewage upon the small area provided, and a portion of it has overflowed into the brook. In December, 1893, the surfaces of the filter-beds remained smooth, and were unprepared by ridging or otherwise for use in cold weather, and during the latter part of the month the sewage froze to the surfaces of some of the beds. The remaining beds were used beyond their capacity and remained constantly covered with sewage, thereby making the filtration continuous, while a considerable quantity of sewage overflowed into the brook. The effluent of the portion of the sewage filtered through the beds deteriorated in quality when cold weather began.

The analyses of sewage and effluent from the Gardner filter-beds, from August to December, 1893, are given in the following table. The averages of analyses for the whole year 1893 show that, of the sewage filtered, 91.1 per cent. of the organic matter (as represented by the albuminoid ammonia) was removed from the sewage by filtration.

*Sewage from Gardner.*

[Parts per 100,000.]

| AMMONIA. |        |             |            | Chlorine. | NITROGEN AS |           | OXYGEN CONSUMED. |           | IRON.      |           | Hardness. |
|----------|--------|-------------|------------|-----------|-------------|-----------|------------------|-----------|------------|-----------|-----------|
| Free.    | Total. | ALBUMINOID. |            |           | Nitrates.   | Nitrites. | Undiluted.       | Filtered. | Undiluted. | Filtered. |           |
|          |        | Dissolved.  | Suspended. |           |             |           |                  |           |            |           |           |
| 1.9200   | .8260  | .5160       | .3100      | 10.77     | .0000       | .0000     | 8.4688           | 3.9105    | -          | -         | 1         |
| 1.7600   | .4380  | .2220       | .2160      | 3.20      | .0000       | .0000     | 4.0132           | 1.8960    | .0750      | .0330     | 2         |
| 3.2000   | .6640  | .3200       | .3440      | 2.97      | .0000       | .0010     | 4.9520           | 2.5740    | .1350      | .0400     | 2.4 3     |
| 2.5600   | .7080  | .3620       | .3400      | 3.40      | .0050       | .0010     | 4.3870           | 1.9680    | .0440      | .0200     | 4.0 4     |
| 2.8800   | .7420  | .4000       | .3420      | 6.08      | .0050       | .0000     | 4.7790           | 2.3490    | .1640      | .0200     | 6.6 5     |
| 1.9200   | .4700  | .2290       | .2440      | 3.22      | .0000       | .0000     | 6.3075           | 3.9150    | .9000      | .0280     | 3.9 6     |
| 2.0240   | .4740  | .2380       | .2360      | 3.43      | .0000       | .0000     | 4.3160           | 2.7390    | .0800      | .0300     | 3.5 7     |
| 2.2490   | .5800  | .2920       | .2880      | 4.96      | .0050       | .0400     | 5.7190           | 3.3110    | .2520      | .0400     | 3.8 8     |
| 2.5680   | .6240  | .3220       | .3020      | 3.00      | .0250       | .0100     | 5.0400           | 3.4000    | .0640      | .0240     | 3.6 9     |
| 1.5680   | .2520  | .1540       | .0980      | 2.90      | .2000       | .0200     | 2.1175           | 1.8095    | .0800      | .0140     | 3.8 10    |
| 1.8797   | .4769  | .2577       | .2192      | 3.48      | .0212       | .0050     | -                | -         | .1142      | .0262     | 3.6 11    |

Odor, offensive. — The sewage was collected as it flowed upon the beds.



*Chemical Examination of Effluent from the*

[Parts per 100,000.]

|    | Number. | Date of Collection. | APPEARANCE.      |                      |        | ODOR.                   |                   |
|----|---------|---------------------|------------------|----------------------|--------|-------------------------|-------------------|
|    |         |                     | Turbidity.       | Sediment.            | Color. | Cold.                   | Hot.              |
|    |         | <b>1893.*</b>       |                  |                      |        |                         |                   |
| 1  | 10,796  | Aug. 14             | Slight, milky.   | Slight, white.       | 0.12   | Decidedly disagreeable. | Offensive.        |
| 2  | 10,921  | Aug. 30             | Slight, milky.   | Very slight.         | 0.10   | Decidedly musty.        | Decidedly musty.  |
| 3  | 11,008  | Sept. 11            | Slight, milky.   | Very slight.         | 0.06   | Distinctly musty.       | Decidedly musty.  |
| 4  | 11,098  | Sept. 27            | Slight, milky.   | Very slight.         | 0.12   | Decidedly musty.        | Decidedly musty.  |
| 5  | 11,181  | Oct. 12             | Slight, milky.   | Very slight.         | 0.03   | Offensive.              | Decidedly musty.  |
| 6  | 11,269  | Oct. 30             | Very slight.     | Very slight.         | 0.02   | Decidedly musty.        | Offensive.        |
| 7  | 11,335  | Nov. 14             | Very slight.     | None.                | 0.02   | Decidedly musty.        | Decidedly musty.  |
| 8  | 11,411  | Nov. 28             | Distinct.        | Considerable, white. | 0.20   | Offensive.              | Offensive.        |
| 9  | 11,488  | Dec. 13             | Slight, milky.   | Slight.              | 0.12   | Distinctly musty.       | Distinctly musty. |
| 10 | 11,557  | Dec. 27             | Distinct, milky. | Slight.              | 0.10   | Decidedly musty.        | Offensive.        |
| 11 | Av.*    | .....               | .....            | .....                | 0.15   | .....                   | .....             |

\* The average given here includes the results of analyses made during the earlier part of the year and printed in the preceding annual report.

*Chemical Examination of Water from Pond Brook above the Gardner Filter-beds.*

[Parts per 100,000.]

| Number. | Date of Collection.      | APPEARANCE.      |               |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |        |            |            | NITROGEN AS |           |           | Oxygen Consumed. | Hardness. |
|---------|--------------------------|------------------|---------------|--------|-------------------------|-------------------|----------|--------|------------|------------|-------------|-----------|-----------|------------------|-----------|
|         |                          | Turbidity.       | Sediment.     | Color. | Total.                  | Loss on Ignition. | Free.    | Total. | Dissolved. | Suspended. | Chlorine.   | Nitrates. | Nitrites. |                  |           |
| 11004   | <b>1893.</b><br>Sept. 11 | Slight.          | Slight.       | 0.18   | 19.70                   | 5.80              | .0032    | .0180  | .0162      | .0018      | 4.99        | .0650     | .0020     | .3198            | 9.1       |
| 11099   | Sept. 27                 | Slight, milky.   | Slight.       | 0.18   | 19.65                   | 3.20              | .0056    | .0182  | .0166      | .0016      | 5.44        | .0400     | .0020     | .4510            | 9.3       |
| 11182   | Oct. 12                  | Slight, milky.   | Slight.       | 0.18   | 24.90                   | 4.80              | .0114    | .0246  | .0214      | .0032      | 6.37        | .0280     | .0023     | .4212            | 11.5      |
| 11270   | Oct. 30                  | Distinct, milky. | V. slight.    | 0.45   | 14.30                   | 3.90              | .0360    | .0250  | .0130      | .0120      | 2.77        | .0800     | .0050     | .5016            | 4.6       |
| 11336   | Nov. 14                  | Slight.          | Cons.         | 0.18   | 10.50                   | 3.20              | .0310    | .0180  | .0130      | .0050      | 2.28        | .0800     | .0010     | .3486            | 4.2       |
| 11412   | Nov. 28                  | Decided.         | Heavy, gray.  | 0.50   | 11.50                   | 3.80              | .0338    | .0550  | .0312      | .0238      | 1.98        | .1250     | .0020     | 2.4080           | 3.6       |
| 11489   | Dec. 13                  | Distinct, milky. | Cons., brown. | 0.15   | 12.70                   | 3.00              | .0640    | .0270  | .0210      | .0060      | 2.41        | .1700     | .0010     | .3184            | 4.2       |
| Av.     | .....                    | .....            | .....         | 0.26   | 16.18                   | 3.96              | .0264    | .0205  | .0189      | .0076      | 3.75        | .0840     | .0022     | .6941            | 6.6       |

Iron, .0299. Odor generally distinctly musty, occasionally offensive. — The samples were collected from the brook above the point where it is crossed by the main sewer leading to the filter-beds.

*Main Underdrain of the Gardner Filter-beds.*

[Parts per 100,000.]

| Residue on Evaporation. | AMMONIA. |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |    |
|-------------------------|----------|------------|-----------|-------------|-----------|------------------|-----------|-------|----|
|                         | Free.    | Albuminoid |           | Nitrates.   | Nitrites. |                  |           |       |    |
| 21.90                   | .4400    | .0310      | 1.97      | 2.4000      | .1600     | .5767            | 5.8       | .0600 | 1  |
| 17.00                   | .1200    | .0230      | 2.00      | 1.5000      | .0240     | .2765            | 4.7       | .0100 | 2  |
| 18.80                   | .0960    | .0240      | 1.61      | 1.4000      | .0100     | .2808            | 6.3       | .0060 | 3  |
| 13.50                   | .0020    | .0150      | 1.65      | 1.0000      | .0020     | .2624            | 4.4       | .0080 | 4  |
| 36.10                   | .1080    | .0180      | 2.41      | 3.9200      | .0800     | .3726            | 11.9      | .0100 | 5  |
| 14.20                   | .2240    | .0120      | 2.17      | 0.8500      | .0600     | .3741            | 3.8       | .0020 | 6  |
| 14.10                   | .0880    | .0090      | 2.42      | 0.8200      | .0100     | .2739            | 3.5       | .0100 | 7  |
| 13.40                   | .6080    | .0660      | 2.43      | 0.5500      | .0500     | .6794            | 2.7       | .0120 | 8  |
| 11.90                   | .8000    | .0360      | 2.01      | 0.3200      | .0020     | .3720            | 2.6       | .0060 | 9  |
| 11.00                   | .8400    | .0290      | 1.96      | 0.2000      | .0020     | .3927            | 3.0       | .0050 | 10 |
| 14.70                   | .4628    | .0423      | 2.03      | 0.7783      | .0257     | -                | 4.1       | .0266 | 11 |

The samples were collected from the main underdrain at the point where it discharges into the brook.

*Chemical Examination of Water from Pond Brook below the Gardner Filter-beds.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.          |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|----------------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.           | Sediment.       | Color. | Total.                  | Loss on Ignition. | Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                      |                 |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 11005   | 1893.<br>Sept. 11   | Slight.              | Slight.         | 0.38   | 20.70                   | 7.10              | .0126    | .0204       | .0182      | .0022      | 4.25      | .2000       | .0030     | .3003            | 8.9       |
| 11100   | Sept. 27            | Slight,<br>milky.    | Cons.,<br>floc. | 0.18   | 17.75                   | 3.25              | .0130    | .0118       | .0114      | .0004      | 4.63      | .2000       | .0025     | .4059            | 8.4       |
| 11183   | Oct. 12             | Slight,<br>milky.    | Slight.         | 0.15   | 39.00                   | 19.50             | .0360    | .0140       | .0090      | .0050      | 6.39      | .2000       | .0045     | .4698            | 11.6      |
| 11271   | Oct. 30             | V. slight,<br>milky. | V. slight.      | 0.45   | 13.20                   | 3.60              | .0560    | .0130       | .0090      | .0040      | 2.64      | .2300       | .0120     | .6177            | 4.4       |
| 11337   | Nov. 14             | Slight.              | Cons.           | 0.18   | 10.60                   | 3.50              | .0420    | .0190       | .0130      | .0060      | 2.27      | .1300       | .0020     | .3735            | 4.2       |
| 11413   | Nov. 28             | Decided.             | Heavy,<br>gray. | 0.50   | 10.70                   | 3.60              | .0816    | .0358       | .0252      | .0106      | 1.84      | .1350       | .0040     | 1.9780           | 3.2       |
| 11490   | Dec 13              | Slight,<br>milky.    | Slight.         | 0.12   | 12.30                   | 3.00              | .1440    | .0240       | .0200      | .0040      | 2.18      | .2000       | .0010     | .3536            | 4.2       |
| Av.     | .....               | .....                | .....           | 0.28   | 17.75                   | 6.08              | .0530    | .0197       | .0151      | .0046      | 3.46      | .1850       | .0041     | .6427            | 6.4       |

Iron, .0222. Odor generally distinctly musty, occasionally offensive. — The samples were collected from the brook below the filter-beds, and below the points where effluent from the filter-beds enters the stream.

## SEWAGE DISPOSAL AT LENOX.

The village of Lenox is situated upon high land, from which the ground slopes to the west, south and east. The first attempt at sewage purification was made in 1876 at a small field upon the westerly slope of the hill. In 1881 the sewage of a few houses on the southerly slope of the hill was conveyed to a small tract of land at the foot of the hill in the town of Stockbridge and there disposed of. In 1888 the principal sewerage system of the town was completed, and by it the sewage is conveyed to a disposal field about two miles east of the village and near the Housatonic River.

This system diverted much of the sewage which formerly went to the small field on the westerly slope of the hill, but, notwithstanding the reduced quantity of sewage going to this field and the small quantity going to the southerly field, the neighboring land owners objected to the use of these areas for sewage disposal, and in December, 1893, works were completed for collecting the sewage of the westerly and southerly slopes at a pumping station west of the village and for pumping it into the main system of sewers leading to the easterly field, which will be the only one in use after the pumping station is operated.

The sewers of Lenox are pipe sewers, and storm-water is excluded from them, except a small quantity of roof-water, which is admitted for flushing purposes. There are said to be about 1,000 persons connected with the system ordinarily, but during the summer season the number is more than doubled.

The main pipe leading from the village to the easterly disposal field is twelve inches in diameter, and ends at a settling tank on the upper portion of the hillside, about 800 feet from the Housatonic River. The tank is of masonry, and has two separate compartments. There are two overflow pipes, one discharging into a pipe connecting with the sub-surface disposal system and the other with a pipe which has a direct connection with the river. There is also a pipe at the bottom of the tank through which the sludge can be run out whenever the tank needs cleaning.

The sewage is disposed of beneath the surface by turning it into stone drains, which are long, nearly-level trenches, filled with stone up to within a short distance of the surface, and above the stone with earth and loam. In addition to the stone the trench contains a six-inch Akron pipe, with open joints, through which the sewage

from the settling tank is conveyed to the drains. These drains vary in length from 200 to 800 feet.

Beneath these stone drains are underdrains, about thirty feet apart, running down hill toward the river. The underdrains are laid with tight joints where they pass beneath the stone drains and with open joints between the drains.

The material of the disposal field is compact and nearly impervious, so that only a portion of the sewage will filter through the ground and the remainder flows out from the stone drains upon the surface through relief pipes which have been laid at their farther ends, or passes off into the river through one of the overflow pipes at the settling tank.

In the following table will be found analyses of sewage and effluent taken from different points of the Lenox system. The sewage is very dilute, owing to the large amount of ground water entering the sewers. It may be noticed, by reference to the table, that the second and third samples, taken from the settling tank after some precipitation had taken place and from the ends of the stone drains, are much less impure than the first sample, which was collected from the main sewer. There was, doubtless, some improvement in quality caused by the passage of the sewage through the settling tank and through the drains, but the bulk of the difference is probably due to the fact that the sewage from the main sewer represented the day sewage, while the samples from the tank and drains represented to a greater extent the night flow, the larger proportion of which is ground water.

*Chemical Examination of Sewage and Effluent from the Lenox Sewage Purification Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |              |        | ODOR.             |                   | RESIDUE ON EVAPORATION. |            |            |                   |            |            |  |
|---------|---------------------|-------------|--------------|--------|-------------------|-------------------|-------------------------|------------|------------|-------------------|------------|------------|--|
|         |                     | Turbidity.  | Sediment.    | Color. | Cold.             | Hot.              | TOTAL RESIDUE.          |            |            | LOSS ON IGNITION. |            |            |  |
|         |                     |             |              |        |                   |                   | Total.                  | Dissolved. | Suspended. | Total.            | Dissolved. | Suspended. |  |
| 1893.   |                     |             |              |        |                   |                   |                         |            |            |                   |            |            |  |
| 11499   | Dec. 11             | Decided.    | Heavy, gray. | 0.28   | Offensive.        | Offensive.        | 38.80                   | 23.00      | 15.80      | 20.20             | 7.20       | 13.00      |  |
| 11500   | Dec. 11             | Distinct.   | Cons. gray.  | 0.15   | Offensive.        | Offensive.        | 21.00                   | 19.20      | 1.80       | 4.80              | 3.00       | 1.80       |  |
| 11501   | Dec. 11             | Distinct.   | Cons. gray.  | 0.15   | Offensive.        | Decidedly musty.  | 20.20                   | 19.00      | 0.60       | 4.20              | 4.20       | 0.00       |  |
| 11502   | Dec. 11             | V. slight.  | Cons., dark. | 0.02   | V. faintly musty. | V. faint or none. | 30.80                   | 29.40      | 1.40       | 5.60              | 5.60       | 0.60       |  |

*Chemical Examination of Sewage and Effluent from the Lenox Sewage  
Purification Works — Concluded.*

[Parts per 100,000.]

| AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | OXYGEN CONSUMED. |           | Hardness. | IRON.       |           |
|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|-----------|-------------|-----------|
| Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. | Unfiltered.      | Filtered. |           | Unfiltered. | Filtered. |
|          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |           |             |           |
| 1.2000   | .2240       | .0980      | .1260      | 1.39      | .0050       | .0000     | 3.2000           | 1.0500    | 11.0      | .1600       | .0180     |
| .6400    | .0700       | .0330      | .0370      | 0.83      | .0000       | .0000     | .7200            | .4800     | 11.3      | .0140       | .0100     |
| .7200    | .0590       | .0330      | .0260      | 0.96      | .0000       | .0010     | .6800            | .4800     | 11.9      | .0200       | .0100     |
| .0240    | .0110       | .0100      | .0010      | 1.36      | .3800       | .0030     | .3840            | .3360     | 15.9      | .2000       | .0000     |

The first sample was collected from the sewer which conveys sewage from the town; the second, from the main settling tank; the third, from the ends of the sub-surface pipes in the stone drains; the last, from the outlet of the underdrains.

### SEWAGE DISPOSAL AT MARLBOROUGH.

The sewerage system of the city of Marlborough (population in 1890, 13,805) was completed late in 1891, and at the end of 1893 there were about 800 connections, including those from all of the larger places, such as hotels, factories, etc. The total length of sewers was 21.58 miles. The so-called separate system was adopted, but no underdrains were laid beneath the sewers and a large amount of ground water enters them at certain seasons of the year.

As the sewage arrives at the disposal field it passes through separating tanks and screens before passing into the distributing pipes. The tanks are built in duplicate, to facilitate cleaning, and, including the portions where the screens are situated, are each about twenty-five feet long, six and one-half feet wide and six feet deep. The screens are of wire and have a one-inch mesh. The elevation of the tanks above the sandy land is such that it was feasible to prepare beds upon which the sludge deposited in the tanks could be turned by gravity.

Thirteen sewage beds, with a total area of 9.6 acres, and six sludge beds, with a total area of 1.7 acres, have been prepared for the disposal of the sewage and the sludge. The material of the beds is finer than that of Framingham and Gardner, and has an

effective size of 0.12 to 0.14 millimeter. The area has a moderate slope toward a small brook, and is from seven to twenty-two feet above it. The beds are thoroughly underdrained by means of parallel lines of four-inch pipes, laid with open joints fifty feet apart and about six feet beneath the surface. All of these drains discharge into the brook before mentioned.

The sewage is ordinary city sewage, varying in strength from time to time with the amount of ground water which enters the sewers. The average quantity is not definitely known, but it was probably in the neighborhood of 400,000 gallons per day during 1893.

Previous to December, 1893, it is said that the beds were generally flooded in turn for twenty-four hours, but that, beginning with this month, they were flooded in turn as before, but for only half a day at a time, and the results obtained from this treatment show, apparently, an improvement. The beds were harrowed twice during the year, about the first of May and the first of November, with a wheel-harrow, to a depth of four to six inches. In November no leveller was attached to the harrow, and the surface was left in alternate ridges and furrows. The grass and weeds were cut several times during the summer, and in the fall several beds, where the weeds grew more luxuriantly, were ploughed before harrowing. A considerable portion of the sludge in the sewage passes through the separating tanks and in time forms a thick scum upon the surfaces of the filter-beds. This scum was removed at irregular intervals during the warmer months, but not during the winter. As a general rule the scum was removed before the surfaces were ploughed or harrowed.

With the aid of the furrowed surfaces and the application of smaller doses the filters disposed of the sewage during the winter months with satisfactory results. At times there has been considerable odor from the sludge beds, but as the beds are a long distance from any road or habitation this has not been a source of complaint.

It has not been the custom to employ a man constantly in caring for the beds, but to employ a man living in the neighborhood to attend to changing the flow of sewage from bed to bed, and to remove the scum from the surfaces of the beds, paying him by the hour for the time spent on the work. The cost of all work done on the beds during the year 1893 amounted to \$497.19.

The averages of the analyses for the whole year 1893 indicate that 94.2 per cent. of the organic matter, as represented by the albuminoid ammonia, was removed from the sewage applied.

*Chemical Examination of*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                    |                     | RESIDUE ON EVAPORATION. |            |            |                   |            |            |        |
|---------|---------------------|------------------|--------------------|---------------------|-------------------------|------------|------------|-------------------|------------|------------|--------|
|         |                     | Turbidity.       | Sediment.          | Color.              | TOTAL RESIDUE.          |            |            | LOSS ON IGNITION. |            |            |        |
|         |                     |                  |                    |                     | Total.                  | Dissolved. | Suspended. | Total.            | Dissolved. | Suspended. |        |
| 1       | 10844               | 1893.<br>Aug. 15 | Thick,<br>opaque.  | V. heavy,<br>dark.  | 0.50                    | 230.40     | 44.40      | 186.00            | 162.80     | 20.00      | 142.80 |
| 2       | 10933               | Aug. 30          | Thick,<br>milky.   | Heavy,<br>dark.     | 0.90                    | 86.70      | 48.30      | 38.40             | 45.90      | 17.50      | 28.40  |
| 3       | 11058               | Sept. 18         | Thick,<br>milky.   | Heavy,<br>dark.     | 0.70                    | 95.30      | 55.90      | 39.40             | 51.60      | 17.70      | 33.90  |
| 4       | 11101               | Sept. 26         | Decided.           | Heavy,<br>dark.     | -                       | 81.00      | 47.80      | 33.20             | 41.40      | 18.00      | 23.40  |
| 5       | 11191               | Oct. 12          | Thick.             | Heavy,<br>dark.     | -                       | 70.00      | 36.80      | 33.20             | 39.80      | 17.20      | 22.60  |
| 6       | 11262               | Oct. 27          | Decided.           | V. heavy,<br>dark.  | -                       | 298.00     | 33.00      | 265.00            | 179.40     | 9.80       | 169.60 |
| 7       | 11339               | Nov. 15          | Decided,<br>milky. | Cons.,<br>heavy.    | 0.90                    | 108.80     | 82.60      | 26.20             | 35.20      | 16.20      | 19.00  |
| 8       | 11425               | Nov. 29          | Distinct.          | Cons.,<br>brown.    | 0.20                    | 24.40      | 23.60      | 0.80              | 5.60       | 5.20       | 0.40   |
| 9       | 11483               | Dec. 12          | Thick.             | V. heavy,<br>brown. | 0.70                    | 66.60      | 39.40      | 27.20             | 33.60      | 11.00      | 22.60  |
| 10      | 11548               | Dec. 26          | Decided.           | Heavy,<br>gray.     | 0.50                    | 44.80      | 26.40      | 18.40             | 21.00      | 9.00       | 12.00  |
| 11      | Av.*                | .....            | .....              | .....               | 0.54                    | 72.36      | 34.93      | 37.43             | 37.27      | 10.83      | 26.43  |

\* This average is for the whole year 1893 and includes the results of analyses made during the earlier portion of the year and printed in the preceding annual report.

*Chemical Examination of Effluent from the*

[Parts per 100,000.]

|    | Number | Date of Collec-<br>tion. | APPEARANCE.     |                              |        | ODOR.             |                                   |
|----|--------|--------------------------|-----------------|------------------------------|--------|-------------------|-----------------------------------|
|    |        |                          | Turbidity.      | Sediment.                    | Color. | Cold.             | Hot.                              |
| 1  | 10846  | 1893.<br>Aug. 15         | Slight.         | Slight, fibrous.             | 0.05   | Distinctly musty. | Decidedly musty.                  |
| 2  | 10846  | Aug. 15                  | Distinct.       | Slight, rusty.               | 0.05   | Distinctly musty. | Decidedly musty.                  |
| 3  | 10934  | Aug. 30                  | Decided.        | Cons., white.                | 0.25   | Offensive.        | Decidedly musty.                  |
| 4  | 10935  | Aug. 30                  | None.           | None.                        | 0.00   | Offensive.        | Faintly musty.                    |
| 5  | 11059  | Sept. 18                 | Decided, milky. | Heavy, rusty.                | 0.50   | Offensive.        | Offensive.                        |
| 6  | 11060  | Sept. 18                 | Decided, milky. | Slight.                      | 0.10   | Offensive.        | Offensive.                        |
| 7  | 11102  | Sept. 26                 | Decided, milky. | Cons., floc.<br>and fibrous. | 0.15   | Offensive.        | Decidedly musty<br>and offensive. |
| 8  | 11103  | Sept. 26                 | Very slight.    | Very slight.                 | 0.00   | Distinctly musty. | Very faint or none.               |
| 9  | 11192  | Oct. 12                  | Distinct.       | Cons., gray.                 | 0.50   | Offensive.        | Offensive.                        |
| 10 | 11193  | Oct. 12                  | Very slight.    | Very slight.                 | 0.02   | Offensive.        | Offensive.                        |

*Sewage from Marlborough.*

[Parts per 100,000.]

| AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | OXYGEN CONSUMED. |           | IRON.       |           | Hardness. |    |
|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|-------------|-----------|-----------|----|
| Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. | Unfiltered.      | Filtered. | Unfiltered. | Filtered. |           |    |
|          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |             |           |           |    |
| 3.2000   | 1.6000      | .2200      | 1.3800     | 7.40      | .0050       | .0000     | 14.2740          | 3.7908    | 1.3000      | .0700     | -         | 1  |
| 3.2000   | .7260       | .2340      | .4920      | 10.00     | .0050       | .0000     | 6.7545           | 3.2785    | .1800       | .0850     | -         | 2  |
| 2.8800   | 1.0460      | .4380      | .6080      | 12.00     | .0050       | .0000     | 8.6100           | 4.7150    | .5800       | .0750     | 5.2       | 3  |
| 2.0000   | 1.1680      | .4300      | .7380      | 8.40      | .0050       | .0000     | 9.1020           | 4.7970    | .2200       | .0740     | 6.3       | 4  |
| 5.0000   | .7200       | .3140      | .4060      | 9.00      | .0050       | .0000     | 7.6140           | 3.3210    | .3600       | .1400     | 6.6       | 5  |
| 1.0800   | 1.7060      | .1800      | 1.5260     | 4.60      | .0000       | .0000     | 22.3590          | 3.2190    | 1.7680      | .3200     | 11.6      | 6  |
| 2.0800   | .8760       | .4340      | .4420      | 32.95     | .0000       | .0000     | 7.7605           | 4.3575    | .2100       | .1400     | 7.6       | 7  |
| .2320    | .0580       | .0350      | .0230      | 3.59      | .9000       | .0300     | 1.5660           | 1.1745    | .1120       | .0600     | 9.6       | 8  |
| 4.1600   | .9740       | .3580      | .6160      | 8.20      | .0100       | .0000     | 6.6406           | 3.0000    | .2740       | .1160     | 7.9       | 9  |
| 1.3440   | .5620       | .1920      | .3700      | 5.21      | .2000       | .1600     | 3.5700           | 1.5960    | .1500       | .0120     | 8.4       | 10 |
| 2.0140   | .6136       | .2164      | .3972      | 7.36      | .1125       | .0286     | -                | -         | .3163       | .0754     | 7.3       | 11 |

Odor, offensive. — The samples were collected from the separating tanks and represent the sewage after a portion of the suspended matter had been separated from it.

*Underdrains of the Marlborough Filter-beds.*

[Parts per 100,000.]

| Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron.  |    |
|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|--------|----|
|                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |        |    |
| 37.20                   | .3920    | .0130       | 6.13      | 1.6250      | .0086     | .2705            | 7.6       | .0280  | 1  |
| 37.90                   | .4000    | .0200       | 5.92      | 1.7500      | .0125     | .2239            | 11.0      | .0330  | 2  |
| 32.40                   | .8400    | .0900       | 7.45      | .8000       | .0760     | .7742            | 7.1       | .0250  | 3  |
| 34.00                   | .2480    | .0080       | 5.82      | 1.6000      | .0300     | .1698            | 9.4       | .0150  | 4  |
| 46.60                   | .9600    | .0460       | 6.92      | 2.2000      | .0200     | .3526            | 10.8      | 1.0500 | 5  |
| 47.00                   | .7000    | .0540       | 7.60      | 2.4000      | .0170     | .5166            | 11.5      | .0400  | 6  |
| 37.70                   | .8000    | .0690       | 7.37      | 2.0000      | .0240     | .6232            | 8.4       | .0250  | 7  |
| 22.10                   | .0240    | .0020       | 4.07      | 1.8000      | .0020     | .2173            | 6.3       | .0000  | 8  |
| 28.70                   | 1.6000   | .2060       | 7.20      | .0300       | .1200     | 1.3648           | 6.4       | .0500  | 9  |
| 38.00                   | .4200    | .0220       | 7.97      | 2.0000      | .0200     | .2227            | 8.3       | .0800  | 10 |



*Chemical Examination of Effluent from the*

[Parts per 100,000.]

|    | Number. | Date of Collection. | APPEARANCE.      |                 |        | ODOR.             |                                   |
|----|---------|---------------------|------------------|-----------------|--------|-------------------|-----------------------------------|
|    |         |                     | Turbidity.       | Sediment.       | Color. | Cold.             | Hot.                              |
| 1  | 11263   | Oct. 27             | Decided.         | Cons., rusty.   | 0.40   | Offensive.        | Offensive.                        |
| 2  | 11264   | Oct. 27             | Distinct.        | Cons., light.   | 0.12   | Offensive.        | Offensive.                        |
| 3  | 11840   | Nov. 15             | Distinct, milky. | Slight.         | 0.15   | Offensive.        | Offensive.                        |
| 4  | 11841   | Nov. 15             | Distinct, milky. | Cons., fibrous. | 0.08   | Offensive.        | Offensive.                        |
| 5  | 11426   | Nov. 29             | Distinct, milky. | Slight.         | 0.12   | Offensive.        | Offensive.                        |
| 6  | 11427   | Nov. 29             | None.            | None.           | 0.00   | Offensive.        | Offensive.                        |
| 7  | 11484   | Dec. 12             | Slight, milky.   | Slight.         | 0.07   | Faintly musty.    | Decidedly musty.                  |
| 8  | 11485   | Dec. 12             | Very slight.     | Very slight.    | 0.05   | Distinctly musty. | Decidedly musty and disagreeable. |
| 9  | 11549   | Dec. 26             | None.            | Very slight.    | 0.00   | Distinctly musty. | Decidedly musty.                  |
| 10 | 11550   | Dec. 26             | Very slight.     | Slight.         | 0.03   | Decidedly musty.  | Decidedly musty.                  |
| 11 | Av.*    | .....               | .....            | .....           | 0.91   | .....             | .....                             |

\* The average given here includes the results of analyses made during the earlier part of the year and printed in the preceding annual report.

*Chemical Examination of Water from the Brook into which the*

[Parts per 100,000.]

|    | Number. | Date of Collection. | APPEARANCE.  |                 |        | ODOR.                   |                     |
|----|---------|---------------------|--------------|-----------------|--------|-------------------------|---------------------|
|    |         |                     | Turbidity.   | Sediment.       | Color. | Cold.                   | Hot.                |
| 1  | 11061   | 1893.<br>Sept. 18   | Very slight. | Cons., rusty.   | 0.28   | Faintly vegetable.      | Faintly vegetable.  |
| 2  | 11062   | Sept. 18            | Very slight. | Cons., brown.   | 0.20   | Decidedly disagreeable. | Decidedly musty.    |
| 3  | 11104   | Sept. 26            | Slight.      | Slight.         | 0.08   | Decidedly musty.        | Decidedly musty.    |
| 4  | 11194   | Oct. 12             | Very slight. | Slight, earthy. | 0.10   | Distinctly musty.       | Decidedly musty.    |
| 5  | 11265   | Oct. 27             | None.        | None.           | 0.12   | Decidedly musty.        | Offensive.          |
| 6  | 11342   | Nov. 15             | Very slight. | Slight.         | 0.10   | Decidedly musty.        | Decidedly musty.    |
| 7  | 11428   | Nov. 29             | Very slight. | Slight, brown.  | 0.45   | Distinctly musty.       | Decidedly musty.    |
| 8  | 11486   | Dec. 12             | Very slight. | Slight.         | 0.18   | Faintly mouldy.         | Distinctly mouldy.  |
| 9  | 11551   | Dec. 26             | Slight.      | Considerable.   | 0.55   | Faintly vegetable.      | Distinctly veg'ble. |
| 10 | Av.*    | .....               | .....        | .....           | 0.22   | .....                   | .....               |

\* Sample No. 11061 is omitted from the average.

*Underdrains of the Marlborough Filter-beds — Concluded.*

[Parts per 100,000.]

| Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |    |
|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|----|
|                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |    |
| 36.80                   | .8000    | .0190       | 7.45      | 1.5000      | .0200     | .5133            | 9.1       | .1500 | 1  |
| 29.50                   | .9000    | .0360       | 6.34      | 1.1000      | .0180     | .4959            | 7.1       | .0160 | 2  |
| 36.00                   | .9280    | .0650       | 6.60      | 1.5000      | .0200     | .7719            | 9.0       | .0400 | 3  |
| 32.50                   | 1.0000   | .0980       | 4.55      | .7000       | .0060     | .8756            | 8.0       | .0420 | 4  |
| 32.40                   | .8000    | .0580       | 5.60      | 1.6000      | .0110     | .6351            | 7.9       | .0050 | 5  |
| 33.50                   | .5600    | .0220       | 6.56      | 1.5000      | .0080     | .2958            | 9.3       | .0100 | 6  |
| 23.90                   | .8800    | .0280       | 4.80      | .8200       | .0050     | .3344            | 6.1       | .0160 | 7  |
| 31.00                   | .6720    | .0260       | 5.60      | 1.3000      | .0080     | .2464            | 8.3       | .0060 | 8  |
| 31.00                   | .2800    | .0140       | 5.23      | 1.0000      | .0120     | .1932            | 8.0       | .0070 | 9  |
| 32.10                   | .4400    | .0140       | 5.77      | 1.2500      | .0100     | .2268            | 7.9       | .0070 | 10 |
| 28.92                   | .5931    | .0353       | 5.08      | 1.0130      | .0234     | -                | 7.7       | .0405 | 11 |

The samples were collected from the underdrains, generally from those beneath the beds to which sewage was being applied at the time.

*Effluent from the Marlborough Sewage Filter-beds is discharged.*

[Parts per 100,000.]

| RESIDUE ON<br>EVAPORATION. |                   | AMMONIA. |             |            |           | Chlorine. | NITROGEN AS |            | Oxygen Consumed. | Hardness. |    |
|----------------------------|-------------------|----------|-------------|------------|-----------|-----------|-------------|------------|------------------|-----------|----|
| Total.                     | Loss on Ignition. | Free.    | ALBUMINOID. |            | Nitrates. |           | Nitrites.   |            |                  |           |    |
|                            |                   |          | Total.      | Dissolved. |           |           |             | Suspended. |                  |           |    |
| 4.30                       | 1.30              | .0000    | .0146       | .0108      | .0038     | 0.31      | .0070       | .0000      | .2132            | 1.7       | 1  |
| 33.70                      | 12.65             | .5040    | .0340       | .0220      | .0120     | 6.19      | .9000       | .0096      | .3198            | 7.9       | 2  |
| 29.20                      | 8.20              | .3680    | .0640       | .0290      | .0350     | 5.55      | 1.4000      | .0540      | .4756            | 7.4       | 3  |
| 26.10                      | 6.00              | .2270    | .0200       | .0190      | .0010     | 4.96      | 1.0000      | .0670      | .3888            | 5.7       | 4  |
| 25.90                      | 6.40              | .3040    | .0320       | .0160      | .0160     | 5.65      | .9500       | .0480      | .4611            | 6.1       | 5  |
| 25.60                      | 6.80              | .4000    | .0300       | .0200      | .0100     | 4.83      | 1.2500      | .0230      | .4150            | 6.4       | 6  |
| 18.20                      | 5.90              | .1400    | .0120       | .0100      | .0020     | 2.80      | 1.0000      | .0120      | .5070            | 4.2       | 7  |
| 20.60                      | 5.30              | .2560    | .0200       | .0160      | .0040     | 3.55      | 1.0000      | .0080      | .3864            | 5.3       | 8  |
| 15.00                      | 5.40              | .1600    | .0210       | .0160      | .0050     | 2.21      | .5500       | .0040      | .6804            | 3.9       | 9  |
| 24.29                      | 7.08              | .2949    | .0291       | .0185      | .0106     | 4.47      | 1.0063      | .0282      | .4543            | 5.9       | 10 |

Iron, .0094. The first sample was collected from the brook above the filter-beds; the remaining samples from the brook below the filter-beds after it had received the effluent therefrom.

## SEWAGE DISPOSAL AT MEDFIELD.

A system of sewage disposal by intermittent filtration was introduced at Medfield in 1886, and was described in the Nineteenth Annual Report of the Board for the year 1887. Up to the end of 1893 connections had been made with one hotel, three houses and a large straw factory, in which, at times, as many as 900 operatives are employed. The original area of the beds was about one acre. The material is mostly coarse gravel. As the level of the ground water is about ten feet below the surface of the filter there are no underdrains. There are four beds, the surfaces of which are some-

*Chemical Examination of*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                  |        | RESIDUE ON EVAPORATION. |            |            |                   |            |            |
|---------|---------------------|-------------|------------------|--------|-------------------------|------------|------------|-------------------|------------|------------|
|         |                     | Turbidity.  | Sediment.        | Color. | TOTAL RESIDUE.          |            |            | LOSS ON IGNITION. |            |            |
|         |                     |             |                  |        | Total.                  | Dissolved. | Suspended. | Total.            | Dissolved. | Suspended. |
| 11167   | 1893.<br>Oct. 11    | Decided.    | Heavy,<br>brown. | 0.70   | 31.60                   | 27.40      | 4.20       | 9.60              | 7.80       | 1.80       |

Odor, offensive. — The sewage was collected as it flowed upon the filter-beds.

*Chemical Examination of Water from a Spring below*

[Parts per 100,000.]

|   | Number. | Date of Collection. | APPEARANCE.  |              |        | ODOR.               |                                  |
|---|---------|---------------------|--------------|--------------|--------|---------------------|----------------------------------|
|   |         |                     | Turbidity.   | Sediment.    | Color. | Cold.               | Hot.                             |
| 1 | 10645   | 1893.<br>July 11    | Very slight. | Very slight. | 0.02   | None.               | None.                            |
| 2 | 10798   | Aug. 14             | Very slight. | Very slight. | 0.08   | None.               | Faintly earthy.                  |
| 3 | 11023   | Sept. 13            | Very slight. | Slight.      | 0.08   | Very faint or none. | Distinctly vegetable and mouldy. |
| 4 | 11168   | Oct. 11             | None.        | Very slight. | 0.03   | Faintly musty.      | Very faint or none.              |
| 5 | 11382   | Nov. 23             | None.        | Slight.      | 0.01   | None.               | Faintly musty.                   |
| 6 | Av...   | .....               | .....        | .....        | 0.04   | .....               | .....                            |

The samples were collected from the spring which is located north of the filter-beds and a little over direction of this spring.

what uneven, each of which, as a general rule, takes the sewage in turn for two days. It was found that there was considerable loam a short distance below the surface of a portion of the beds which eventually became clogged. In the summer of 1893 this loam was removed and replaced with coarse gravel, and the area of the filter increased about one-third.

No trouble has arisen from odors. In the following tables will be found analyses of the sewage, and of the effluent taken from a spring a short distance below the filter. The effluent is of excellent quality, and no deterioration is shown by the analyses when compared with those made in 1887, after the works had been in operation for a comparatively short time.

*Sewage from Medfield.*

[Parts per 100,000.]

| AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | OXYGEN CONSUMED. |           | IRON.       |           | Hardness. |
|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|-------------|-----------|-----------|
| Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. | Unfiltered.      | Filtered. | Unfiltered. | Filtered. |           |
|          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |             |           |           |
| 2.5600   | .3780       | .2000      | .1780      | 1.58      | .0030       | .0000     | 2.6730           | 1.8630    | .0400       | .0300     | 3.0       |

The straw shop was not running at the time the sample was collected.

*the Filtration Area of the Medfield Sewerage System.*

[Parts per 100,000.]

| Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |   |
|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|---|
|                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |   |
| 11.70                   | .0010    | .0048       | 0.94      | .1500       | .0000     | .0584            | 3.1       | .0080 | 1 |
| 11.70                   | .0032    | .0068       | 1.00      | .2500       | .0020     | .1833            | 3.8       | .0000 | 2 |
| 15.10                   | .0010    | .0098       | 1.37      | .1000       | .0030     | .2028            | 5.4       | .0070 | 3 |
| 12.10                   | .0014    | .0044       | 1.20      | .1350       | .0013     | .1620            | 4.3       | .0020 | 4 |
| 10.15                   | .0000    | .0034       | 1.05      | .1900       | .0003     | .1512            | 3.6       | .0000 | 5 |
| 12.15                   | .0013    | .0058       | 1.11      | .1650       | .0013     | .1515            | 4.0       | .0030 | 6 |

260 feet from the edge of the nearest bed. The ground where the filter-beds are located slopes in the

*Daily Bacterial Results, Lawrence City Water—Continued.*

Bacteria per Cubic Centimeter.]

| DATE—1895.        | In River Water. | IS FILTERED WATER FROM |                   |                   |                            | Condition of Surface when Pumps were Stopped. | Loss of Head, Feet. |
|-------------------|-----------------|------------------------|-------------------|-------------------|----------------------------|-----------------------------------------------|---------------------|
|                   |                 | City Filter.           | Reservoir Outlet. | Tap at City Hall. | Tap at Experiment Station. |                                               |                     |
| December 1, . . . | -               | -                      | -                 | -                 | -                          | Drained.                                      | -                   |
| 2, . . .          | 5,500           | 61                     | 67                | 68                | 88                         | Covered.                                      | 4.8                 |
| 3, . . .          | 4,000           | 35                     | 51                | 66                | 41                         | Drained.                                      | 5.1                 |
| 4, . . .          | 4,300           | 67                     | 50                | 44                | 62                         | Covered.                                      | 4.9                 |
| 5, . . .          | 4,900           | 49                     | 65                | 55                | 42                         | Covered.                                      | 4.9                 |
| 6, . . .          | 11,000          | 38                     | 43                | 53                | 55                         | Drained.                                      | 5.3                 |
| 7, . . .          | 4,500           | 87                     | 63                | 69                | 43                         | Covered.                                      | 5.6                 |
| 8, . . .          | -               | -                      | -                 | -                 | -                          | -                                             | -                   |
| 9, . . .          | 3,100           | 51                     | 50                | 47                | 37                         | Covered.                                      | 4.8                 |
| 10, . . .         | 3,400           | 50                     | 41                | 38                | 47                         | Covered.                                      | 5.1                 |
| 11, . . .         | 4,300           | 55                     | 64                | 60                | 46                         | Drained.                                      | 5.5                 |
| 12, . . .         | 3,400           | 64                     | 35                | 39                | 36                         | Covered.                                      | 5.4                 |
| 13, . . .         | 3,500           | 112                    | 71                | 37                | 49                         | Covered.                                      | 5.3                 |
| 14, . . .         | 6,100           | 210                    | 64                | 51                | 51                         | Covered.                                      | -                   |
| 15, . . .         | 7,200           | 180                    | 79                | 61                | 47                         | -                                             | 4.6                 |
| 16, . . .         | 4,500           | 118                    | 56                | 41                | 56                         | Covered.                                      | 4.6                 |
| 17, . . .         | -               | -                      | -                 | -                 | -                          | Covered.                                      | 4.4                 |
| 18, . . .         | 6,700           | 92                     | 62                | 53                | 47                         | Covered.                                      | 5.3                 |
| 19, . . .         | 11,200          | 130                    | 40                | 50                | 53                         | Drained.                                      | 5.8                 |
| 20, . . .         | 6,100           | 41                     | 51                | 42                | 34                         | Drained.                                      | 5.8                 |
| 21, . . .         | 5,000           | 66                     | 49                | 48                | 48                         | Covered.                                      | 5.8                 |
| 22, . . .         | -               | -                      | -                 | -                 | -                          | -                                             | -                   |
| 23, . . .         | 7,800           | 105                    | 67                | 74                | -                          | Covered.                                      | 5.2                 |
| 24, . . .         | 10,000          | 124                    | 84                | 70                | 67                         | Covered.                                      | 5.5                 |
| 25, . . .         | -               | -                      | -                 | -                 | -                          | -                                             | -                   |
| 26, . . .         | 7,500           | 109                    | 85                | 80                | 104                        | Covered.                                      | 5.3                 |
| 27, . . .         | 11,200          | 52                     | 145               | 68                | 52                         | Drained.                                      | 6.5                 |
| 28, . . .         | 11,500          | 76                     | 82                | 72                | 95                         | Drained.                                      | 6.5                 |
| 29, . . .         | -               | -                      | -                 | -                 | -                          | Covered.                                      | 5.9                 |
| 30, . . .         | -               | -                      | -                 | 77                | 76                         | Drained.                                      | 5.8                 |
| 31, . . .         | 8,300           | 55                     | 78                | 80                | 68                         | Drained.                                      | 6.1                 |

After this clogging occurred provision was made for screening the sewage so as to prevent the entrance of coarse substances into the eight-inch pipes.

In the summer of 1893 some further changes were made. Two settling tanks, each ten feet long and six feet wide, were added, and the length of the filtration area was extended to 450 feet, making the total area 1.55 acres. All of the sub-surface distributing pipes were relaid, and over the joints of the pipes, in all cases, were placed pieces of half-pipe of larger diameter. An eight-inch pipe was laid along each side of the filtration area and connected with the ends of all of the three-inch distributing pipes. Gates have been placed at the lower ends of all of the eight-inch pipes, and about once a week, usually on washing day, they have been opened with a view to flushing the entire system of pipes. The sewage used in flushing discharges upon a thin filter-bed about fifty feet square. It has been the custom to empty the settling tanks once a week, and at these times the liquid matter is discharged upon a small filter-bed constructed for this purpose, while the semi-solid portions remaining are run into carts and removed to some woods at a considerable distance from the buildings where they are disposed of by composting. There are about 500 people connected with this system. There have been no indications of clogging in the sub-surface pipes since the changes were made.

In the following tables will be found analyses of the Wellesley sewage, and of samples of water taken from a small brook, into which some of the effluent finds its way, above and below the filter-bed.

*Sewage from Wellesley.*

[Parts per 100,000.]

| AMMONIA. |        |             |            | Chlorine. | NITROGEN AS |           | OXYGEN CONSUMED. |           | IRON.       |           | Hardness. |
|----------|--------|-------------|------------|-----------|-------------|-----------|------------------|-----------|-------------|-----------|-----------|
| Free.    | Total. | ALBUMINOID. |            |           | Nitrates.   | Nitrites. | Unfiltered.      | Filtered. | Unfiltered. | Filtered. |           |
|          |        | Dissolved.  | Suspended. |           |             |           |                  |           |             |           |           |
| 5.4000   | 2.8800 | 1.3300      | 1.5500     | 24.00     | .0000       | .0000     | 31.7550          | 16.0950   | .1700       | .1000     | 16.4      |

settling tank and before the sewage entered the flush tank.

*Chemical Examination of Water from the Brook above and below the Wellesley Sewage Filtration Area.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                    |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|--------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment.          | Color. | Total.                          | Loss on<br>ignition. | Free.    | ALBUMINOID. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                     |                    |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 11420   | 1893.<br>Nov. 29    | Slight.             | Slight.            | 1.30   | 11.85                           | 5.65                 | .0148    | .0584       | .0546      | .0038           | 0.82      | .1700          | .0003     | 1.7139           | 3.8       |
| 11421   | Nov. 20             | Slight.             | Cons.,<br>fibrous. | 1.10   | 14.00                           | 5.20                 | .0416    | .0700       | .0422      | .0278           | 1.43      | .4500          | .0009     | 1.5573           | 4.6       |
| 11422   | Nov. 29             | Distinct,<br>milky. | Cons.,<br>rusty.   | 1.00   | 10.30                           | 3.50                 | .0520    | .0200       | .0152      | .0048           | 1.22      | .1000          | .0015     | 0.5829           | 4.0       |

Iron, .0878. Odor of the first sample, none; of the second, faintly earthy; of the last, strong of gas liquors. On heating, the odor of the first two samples was distinctly vegetable, but the last was unchanged.—The first sample was collected from the brook above the filter-beds; the second, near the sludge bed, and the last, near the gas works, about 150 feet above the point where the brook enters Waban Lake.

### SEWAGE DISPOSAL AT WESTBOROUGH.

The construction of the sewerage system of the town of Westborough (population in 1890, 5,195) was begun in 1891, and up to the end of the year 1893 ninety-one connections had been made with the sewers, forty-three of which were from the larger places, such as business blocks, factories, etc. The main sewer leading from the town to the place of disposal passes through low wet ground, and receives a large amount of ground water.

The sewage is disposed of upon land located on the right bank of the Assabet River, in the north-westerly part of the town. About thirty-three acres were taken by the town for sewage-disposal purposes, 17.5 of which may be classed as swamp or meadow subject to flooding at times of high water, its surface being at an elevation of three feet or less above the ordinary level of the river. About six acres of the upland is at too great an elevation to be reached by gravity without grading.

The sewage is conducted to a settling tank on the disposal area. The tank is of masonry, built in two compartments, and has a total capacity of less than 1,000 gallons. Two filter beds, having a total area of a little over two acres, were prepared in 1892 by stripping off most of the loam and filling with coarse sand or gravel to depths varying from about thirty inches at the lower end to about a foot at

the other end. The material beneath the filling is a fine, compact sand almost impervious to water. The surfaces of the beds are from six to six and one-half feet above the ordinary level of the surface of the water in the Assabet River, opposite the sewage field. During the prevalence of high water in the spring the surface of the water in the river rises to about three feet above the ordinary level.

Sewage was applied to the beds in April, 1893, and it was found that the sand beneath the artificial and porous surface layer was so fine that it remained saturated and also kept the material above it saturated for weeks after the application of sewage had ceased. It is said that these beds could be made to take the whole flow of sewage for about a week by filling them to the level of the top of the embankment. On discontinuing the use of the beds in July it took eight weeks for the sewage to disappear.

To obtain material to prepare the filter beds as above described, a pit was excavated in a gravel ridge in the higher portion of the area owned by the town. Into this gravel pit, covering an area of approximately 15,000 square feet, the bottom of which is said to be six inches above the ground-water level, the sewage has been discharged from time to time, and it has been filled to the level of the bottom of the sewage carrier, or approximately six feet deep, forming a huge cesspool, the effluent from which appeared in the form of a flowing spring, on the surface of a piece of low land fifty to seventy-five feet from the edge of the excavation. During the year 1893 sewage has also been discharged from time to time on a portion of the unprepared ground and allowed to flow over its surface to find its way to the meadows.

The selectmen of the town applied to the State Board of Health, Sept. 18, 1893, stating that the former advice of the Board had not been carried out, and requesting the Board to make another examination of the present sewage-disposal works at Westborough, and advise the town farther in the matter of sewage disposal. The reply of the Board to this application may be found on page 86 of this volume.

Toward the end of the year the surfaces of the two filter beds were raised from one to two feet by the addition of more coarse sand, and two six-inch underdrains were placed beneath the beds at depths of from three to five feet beneath the surface. In addition to this work, two additional beds, each about an acre in area, were prepared between the settling tank and the river. The surfaces



of the new beds were levelled to some extent, and in each two four-inch underdrains were laid three feet below the surface at the upper ends and five feet below at the lower ends. It is said that some of the mud in the low places on the area covered by these beds was removed while preparing the beds and replaced with gravel from a knoll situated partly within the limits of the beds. There is considerable loam remaining on each bed. Sewage was distributed

*Chemical Examination of Sewage from*

[Parts per 100,000.]

|   | Number. | Date of Collection. | APPEARANCE. |                 |        | RESIDUE ON EVAPORATION. |            |            |                   |            |            |
|---|---------|---------------------|-------------|-----------------|--------|-------------------------|------------|------------|-------------------|------------|------------|
|   |         |                     | Turbidity.  | Sediment.       | Color. | TOTAL RESIDUE.          |            |            | LOSS ON IGNITION. |            |            |
|   |         |                     |             |                 |        | Total.                  | Dissolved. | Suspended. | Total.            | Dissolved. | Suspended. |
| 1 | 11171   | 1893.<br>Oct. 11    | Decided.    | Heavy,<br>gray. | 1.20   | 31.00                   | 16.40      | 14.60      | 17.00             | 7.80       | 9.20       |
| 2 | 11406   | Nov. 28             | Decided.    | Cons., gray.    | 0.20   | 10.00                   | 8.00       | 2.00       | 4.20              | 2.80       | 1.40       |

Odor, offensive. — The samples were collected from the

*Chemical Examination of Effluent from the*

[Parts per 100,000.]

|   | Number. | Date of Collection. | APPEARANCE. |               |        | ODOR.                            |                                 |
|---|---------|---------------------|-------------|---------------|--------|----------------------------------|---------------------------------|
|   |         |                     | Turbidity.  | Sediment.     | Color. | Cold.                            | Hot.                            |
| 1 | 11174   | 1893.<br>Oct. 11    | Distinct.   | Considerable. | 1.20   | Very disagreeable.               | Offensive.                      |
| 2 | 11407   | Nov. 28             | Slight.     | Very slight.  | 0.03   | Tarry.                           | Offensive.                      |
| 3 | 11408   | Nov. 28             | Distinct.   | Cons., green. | 0.50   | Distinctly vegetable and mouldy. | Decidedly vegetable and grassy. |
| 4 | Av...   | .....               | .....       | .....         | 0.58   | .....                            | .....                           |

The first and last samples were collected from the spring below the gravel pit; the second

upon the two new beds from trenches along the sides and by furrows across the beds. The distribution, however, at the time the beds were examined was very uneven.

In the following table will be found analyses of samples of the sewage, of the effluent from the gravel pit collected at the spring already mentioned and of samples collected from the Assabet River above and below the disposal area.

*the Westborough Sewerage System.*

[Parts per 100,000.]

| AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | OXYGEN CONSUMED. |           | IRON.       |           | Hardness. |   |
|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|-------------|-----------|-----------|---|
| Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. | Unfiltered.      | Filtered. | Unfiltered. | Filtered. |           |   |
|          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |             |           |           |   |
| 1.7600   | .3080       | .2200      | .0880      | 3.81      | .0050       | .0000     | 3.7665           | 2.7540    | .1200       | .0360     | 3.6       | 1 |
| 0.3840   | .0720       | .0500      | .0220      | 0.73      | .0350       | .0050     | 1.6770           | 1.0320    | .4100       | .0280     | 3.2       | 2 |

sewer at the point where it discharges upon the filter-beds.

*Beds of the Westborough Sewerage System.*

[Parts per 100,000.]

| Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |          | Oxygen Consumed. | Hardness. | Iron. |   |
|-------------------------|----------|-------------|-----------|-------------|----------|------------------|-----------|-------|---|
|                         | Free.    | Albuminoid. |           | Nitrate.    | Nitrite. |                  |           |       |   |
| 10.20                   | .0008    | .0264       | 2.84      | .0000       | .0000    | 1.0732           | 2.2       | .1180 | 1 |
| 5.70                    | .2000    | .0220       | 0.86      | .0400       | .0040    | .2322            | 2.3       | .0000 | 2 |
| 9.10                    | .1960    | .0220       | 2.00      | .0000       | .0000    | .6364            | 2.5       | .0210 | 3 |
| 8.33                    | .1323    | .0235       | 1.90      | .0133       | .0013    | .6473            | 2.8       | .0463 | 4 |

sample from the underdrain of new filter-beds which had been in use but six days.

*Chemical Examination of Water from the Assabet River above and below the Westborough Sewage Filter-beds.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on ignition. | Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
|         | 1893.               |             |            |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 10840   | Aug. 16             | V. slight.  | V. slight. | 0.45   | 5.00                    | 1.80              | .0028    | .0166       | .0140      | .0026      | .23       | .0030       | .0000     | .5986            | 1.3       |
| 11172   | Oct. 11             | V. slight.  | Slight.    | 0.45   | 4.65                    | 1.85              | .0000    | .0188       | .0140      | .0048      | .36       | .0000       | .0000     | .5386            | 1.8       |
| 11173   | Oct. 11             | V. slight.  | Slight.    | 0.45   | 4.40                    | 1.70              | .0000    | .0182       | .0152      | .0030      | .38       | .0000       | .0000     | .5184            | 1.8       |
| 11409   | Nov. 28             | V. slight.  | V. slight. | 0.90   | 5.80                    | 3.00              | .0280    | .0290       | .0240      | .0050      | .47       | .0000       | .0003     | 1.1266           | 1.8       |

Odor, distinctly vegetable and mouldy or unpleasant. — The first two samples were collected from the river above the filter-beds and the last two from the river below the filter-beds.

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CHEMICAL PRECIPITATION OF SEWAGE

AT THE

WORLD'S COLUMBIAN EXPOSITION,

CHICAGO, 1893.

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By ALLEN HAZEN,

CHEMIST, DEPARTMENT OF WATER SUPPLY, SEWERAGE AND FIRE PROTECTION.

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# CHEMICAL PRECIPITATION OF SEWAGE AT THE WORLD'S COLUMBIAN EXPOSITION, CHICAGO, 1893.

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The sewage disposal works at the World's Columbian Exposition were described in the "Engineering News" of Aug. 3, 1893, which contains drawings showing many of the details of construction and arrangement.

The works were designed and built under the direction of W. S. MacHarg, C.E., engineer for water supply, sewerage and fire protection, Mr. C. M. Wilkes being first assistant engineer, and the construction of the plant and the operation of the machinery being superintended by Mr. C. E. Chester. The writer was employed to superintend the precipitation of the sewage after the construction of the works was practically completed.

The works consisted in brief of four cylindrical iron settling tanks of the Rückner-Rothe type, 32 feet high and 32 feet in diameter, with conical bottoms, which, in a height of 22 feet, tapered from 32 feet to 6 feet (see diagram on following page†). The total height was thus 54 feet, and the capacity of each tank, as ordinarily used with sewage standing 18 inches below the top, was 237,000 gallons.

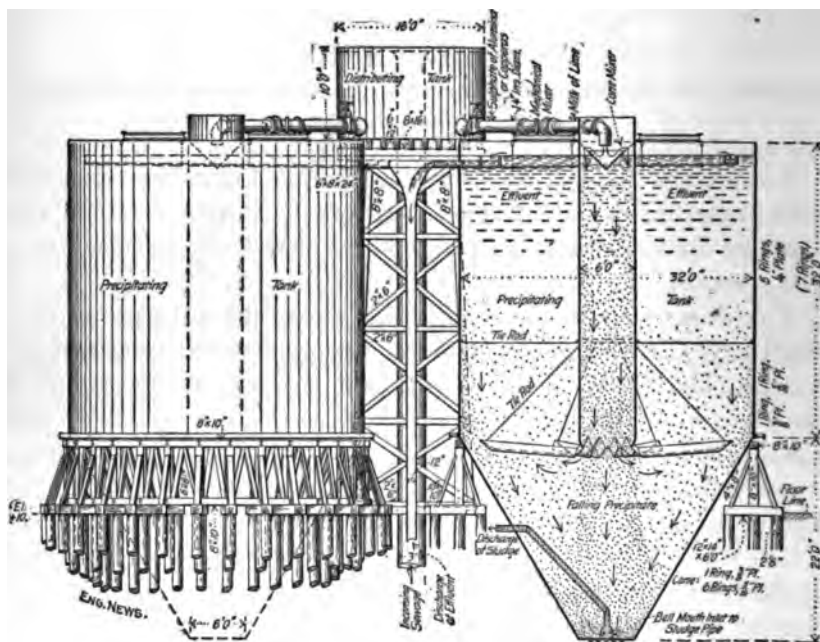
The sewage from the various buildings on the Exposition grounds was forced by Shone ejectors into the iron sewers which terminated in a receiving tank 16 feet in diameter and 10 feet deep, where the sewage was screened and afterward passed through the four pipes which conveyed it to the different settling tanks, receiving and be-

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\* Mr. Hazen, at the time of his appointment at Chicago, was chemist in charge of the Experiment Station of the Massachusetts State Board of Health at Lawrence. He held the position at Chicago during a leave of absence granted by the Board.

† The plate from which this diagram is printed was kindly furnished by the Engineering News Publishing Company.

coming mixed with the necessary chemicals on the way. The mixed and precipitated sewage then passed down through central cylinders, 6 feet in diameter, to points near the bottoms of the tanks, where it was distributed by sheet-iron arms and the precipitate settled to the bottom, while the clarified liquid, ready for discharge into the lake, slowly rose to the top, where it was removed by a set of troughs drawing as nearly as possible equal quantities of effluent from equal



areas of surface to give a uniform and regular upward movement to the sewage in the tanks. The sludge which settled to the conical-shaped bottom was expected to slide to the point of the cone, where there was an outlet through which it could be drawn off from time to time for pressing without interrupting the continuous action of the tanks.

The filter-presses, which were exhibited by the Perrin Company, Chicago, were made by the G. H. Bushnell Company, Thompsonville, Conn., and produced at each operation fifty cakes of sludge 36 inches in diameter and about  $1\frac{1}{4}$  inches thick, weighing about 47 pounds each. The central passages in the filter-presses were 4 inches in diameter, but it was found that rags and cotton waste which passed

the bars in the screen, about three-fourths of an inch apart, would frequently stop the 4-inch holes in the plates, allowing the pressure to accumulate on one side of the plate until it broke. The delay and expense of replacing plates was considerable, and it was not until the screen was covered with a finer wire screen to retain all rags and the holes in the plates were cut out to six inches in diameter that satisfactory working was obtained. The quantity of sludge which could be pressed with these presses was much below the anticipated amount, and the failure to press promptly the sludge as produced was often the limit, during a large part of the summer, of the efficiency of the plant.

The sludge cake, together with the garbage from the grounds, was burned in an Engle crematory near the sewage-disposal works.

The object of having four separate settling tanks, each of them with its independent appliances for mixing chemicals, was to allow the simultaneous application of different chemicals to sewage of precisely the same composition, and to secure in that way definite comparisons between the different chemicals when working upon a large scale. Such experiments were made almost from the first, but it soon became apparent that, within wide limits at least, the chemicals employed were not the controlling or even the leading factor in the results obtained, and that the differences between the various quantities or kinds of chemicals were often far more than offset by other conditions, which will be described beyond, over which we had less control. In this way, our investigations, instead of throwing light upon the questions which we had propounded, have been mainly confined to quite another set of problems which were scarcely anticipated before they presented themselves. We found it necessary to study, not so much how to produce a precipitate by adding chemicals to the sewage, as how to make it settle to the bottom and stay there until it could be removed and pressed.

#### MANNER OF DELIVERY OF THE SEWAGE AT THE WORKS.

One of the most troublesome circumstances in connection with the plant was the irregular manner in which the sewage was delivered at the works. The flow of sewage, instead of coming regularly, was subject to violent fluctuations, due to the method of collection and to the construction of the force main. The sewage was forced into



this main by twenty-six pairs of Shone ejectors located at various points on the grounds. These were operated by compressed air from a central station in Machinery Hall, and each was furnished with an automatic appliance to shut off the air as soon as the tank was sufficiently emptied. For some reason these valves often failed to act as was intended and the compressed air followed the sewage into the pipes in large quantity, pushing ahead of it the sewage in the sewer pipes with great rapidity to the precipitation works. The sewer pipes having been laid without attention to grades, contained numerous summits and depressions, and the air rapidly accumulated in the summits until finally the bulk of the sewage in the sewers had been forced to the works when at last the air commenced to come through the vertical discharge pipe. This at once relieved the pressure and the large volume of air contained in the sewers, now rapidly expanding and mixed with varying proportions of sewage, came out with explosive violence, throwing quantities of sewage into the air and even through the roof. The violence of these "blows" can be somewhat appreciated when it is stated that most of the glass in the roof twenty feet above the outlet was broken by these "blows" within a few days after the works were started, and that among other debris, a piece of lead weighing nine pounds, which had been accidentally left in the sewers, was carried up through and discharged from the vertical pipe fifty feet in height.

The number of days in each month on which such "blows" occurred, usually from one to ten and sometimes even as many as twenty "blows" occurring in a single day, was as follows:—

|                   |          |                 |                              |    |   |   |   |
|-------------------|----------|-----------------|------------------------------|----|---|---|---|
| April (14 to 30), | 13 days, | or 76 per cent. | of the total number of days. |    |   |   |   |
| May,              | 23       | "               | "                            | 74 | " | " | " |
| June,             | 13       | "               | "                            | 43 | " | " | " |
| July,             | 15       | "               | "                            | 48 | " | " | " |
| August,           | 19       | "               | "                            | 61 | " | " | " |
| September,        | 22       | "               | "                            | 73 | " | " | " |
| October,          | 26       | "               | "                            | 84 | " | " | " |

The average maximum hourly flow of sewage was about 6 per cent. of the total daily flow, and the latter never exceeded 3,200,000 gallons; it may thus be said that the normal flow of sewage which should have been obtained, if it had been delivered at the same rate as it was produced, would not have exceeded 190,000 gallons per hour, and this quantity would produce a velocity of only a foot a second

in the three-foot discharge pipe. Actually, the ordinary discharge between "blows" was much less than this, and allowed much of the suspended matter of the sewage to be deposited on the bottom of the sewer. Every time a "blow" occurred the matter which had been deposited since the previous "blow" was flushed out, and at these times sewage was obtained two or three times as concentrated as at other times. Thus for short intervals enormous quantities of highly concentrated sewage were received at the works, and the rest of the time only a reduced flow of a sewage from which the sludge had been partially removed, and frequently for a time after the "blows" occurred there was no flow at all.

### PRECIPITANTS EMPLOYED.

The chemicals employed as precipitants were copperas or crude ferrous sulphate, crude alum or sulphate of alumina, a crude ferric sulphate, and lime. The copperas, alum or ferric sulphate was first added to the sewage, which then passed through a mechanical mixer containing a rapidly revolving paddle-wheel, and then received the lime. The mechanical mixers for mixing the chemicals with the sewage had no advantage over a fishway, and were more expensive and troublesome in construction and operation. The chemicals were added mainly in accordance with the principles given in the special report of the Massachusetts State Board of Health for 1890;\* but owing to variation in the market prices of the various chemicals and the freight the relative costs were changed somewhat.

The analyses and costs of the various chemicals employed, together with many other data, are given in the Appendices following (pages 613-624). In calculating the costs the actual costs of chemicals delivered in Chicago are given in each case, although much lower prices were paid for some of the later lots than at the beginning.

It was found that the sludge produced with copperas and lime as precipitants was much more easily pressed than that with alum, even when used with lime; and as the cost of pressing the sludge exceeded the cost of precipitating, copperas was a more economical precipitant than alum. For the same reason more lime was used with alum than was necessary to produce the best effluent, because

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\* Experiments upon the Chemical Precipitation of Sewage, by Allen Hazen. Special Report of the Massachusetts State Board of Health upon Purification of Sewage and Water, 1890.

the sludge produced in presence of an excess of lime could be much more easily pressed, and the extra lime applied to the sewage was cheaper than the labor on the presses. For equal costs of treatment copperas and alum produced equally good effluents, although the effluent from copperas had more color (due to the suspended iron) than that from alum. The only ferric sulphate obtainable contained much free acid, with a disappointingly low percentage of soluble ferric oxide, and the rather poor results obtained should not be taken as disparaging the use of a better quality of reagent.

Two kinds of lime were employed, a very pure lime from Hannibal, Mo., and a local dolomite lime which was used at first, and on one or two occasions afterwards when the stock of Hannibal lime was exhausted. This lime cost only two-thirds as much and was hardly six-tenths as strong as the Hannibal lime, and to avoid unnecessarily complicating the figures in the tables given beyond, when dolomite lime was used, its weight is reckoned as its equivalent in cost of Hannibal lime, or two-thirds its actual weight.

#### MEASUREMENT AND COMPOSITION OF SEWAGE AND EFFLUENTS.

The quantities of sewage passing each tank were determined by hourly weir measurements, so that the total daily flow of sewage was calculated from ninety-six readings. Records were kept of all these quantities, and of the weights of the chemicals employed.

Many samples of sewage and of the different effluents were analyzed to determine the efficiency of the treatments, but to avoid an unnecessarily large volume of data, only the monthly averages are given below, as it is believed that no additional information of importance would be obtained from a more detailed presentation. The method of obtaining the samples was to mix eight pint samples in a gallon bottle, the eight portions being taken at such intervals that one-eighth of the total daily flow passed between each two of them. The samples of effluent were taken in the same way, but as much later than the corresponding sewage samples as the average time required for the sewage to pass through the tanks.

The analyses are believed to represent correctly the character of effluent as discharged into Lake Michigan; but, owing to the violent fluctuations in the flow of the sewage mentioned above, the samples of sewage taken represent in general the sewage between "blows,"

when it did not contain the full amount of sludge, as, owing to the personal danger involved, satisfactory samples could not be obtained during "blows," and even if they could have been collected, it would have been impossible to determine how much sewage actually had the composition indicated by the samples. For this reason the results for loss on ignition, albuminoid ammonia and oxygen consumed in the unfiltered sewage are too low and the results of efficiency given must be taken as relative instead of absolute. The soluble constituents, including chlorine and free ammonia, were not affected in the least by sedimentation.

The averages of analyses of sewage and effluents by four weeks' periods are as follows : —

## Period I. June 10 to July 7, 1893.

[Parts per 100,000.]

|                                     | Tempera-<br>ture.<br>Degrees<br>Centigrade. | APPEARANCE. |        | RESIDUE ON EVAPORATION. |             |            |                   |             |            | Chlorine. | Oxygen Consumed. | NITROGEN AS<br>ALBUMINOID<br>AMMONIA. |             |        |             |            | Nitrates. | Nitrites. | Bacteria per Cubic<br>Centimeter. |               |
|-------------------------------------|---------------------------------------------|-------------|--------|-------------------------|-------------|------------|-------------------|-------------|------------|-----------|------------------|---------------------------------------|-------------|--------|-------------|------------|-----------|-----------|-----------------------------------|---------------|
|                                     |                                             | Turbidity.  | Color. | TOTAL RESIDUE.          |             |            | LOSS OF IGNITION. |             |            |           |                  | Suspended.                            | Dissolved.* | Total. | Dissolved.* | Suspended. |           |           |                                   | Free Ammonia. |
|                                     |                                             |             |        | Total.                  | Dissolved.* | Suspended. | Total.            | Dissolved.* | Suspended. |           |                  |                                       |             |        |             |            |           |           |                                   |               |
|                                     |                                             |             |        |                         |             |            |                   |             |            |           |                  |                                       |             |        |             |            |           |           |                                   |               |
| Sewage, . . . . .                   | 18.3                                        | .08         | 1.20   | 58.3                    | 38.5        | 19.8       | 28.9              | 11.4        | 17.6       | 6.32      | 3.05             | .80                                   | .29         | .51    | 3.67        | 0          | 0         | 5,600,000 |                                   |               |
| Average of all effluents, . . . . . | 18.6                                        | .17         | .64    | 42.7                    | 38.1        | 4.6        | 13.1              | 9.8         | 3.3        | 5.00      | 1.37             | .36                                   | .24         | .12    | 2.98        | 0          | 0         | 6,200,000 |                                   |               |
| Effluent of Tank 1, . . . . .       | 18.5                                        | .17         | .98    | 43.2                    | 37.5        | 5.7        | 13.9              | 10.0        | 3.9        | 5.31      | 1.45             | .38                                   | .24         | .14    | 3.10        | 0          | 0         | 5,400,000 |                                   |               |
| “ “ 2, . . . . .                    | 18.7                                        | .20         | .54    | 44.0                    | 38.6        | 5.4        | 13.6              | 9.4         | 4.2        | 5.25      | 1.44             | .39                                   | .23         | .16    | 3.10        | 0          | 0         | 7,500,000 |                                   |               |
| “ “ 4, . . . . .                    | 18.6                                        | .14         | .40    | 40.9                    | 38.1        | 2.8        | 11.9              | 10.1        | 1.8        | 4.42      | 1.22             | .33                                   | .24         | .08    | 2.74        | 0          | 0         | 5,900,000 |                                   |               |

## Period II. July 8 to August 4, 1893.

| Sewage, . . . . .                   | .61 | 1.10 | 47.4 | 31.9 | 15.6 | 22.8 | 10.3 | 12.5 | 4.65 | 2.45 | .62 | .23 | .39 | 2.52 | 0 | 0 | 3,300,000  |
|-------------------------------------|-----|------|------|------|------|------|------|------|------|------|-----|-----|-----|------|---|---|------------|
|                                     |     |      |      |      |      |      |      |      |      |      |     |     |     |      |   |   |            |
|                                     |     |      |      |      |      |      |      |      |      |      |     |     |     |      |   |   |            |
| Average of all effluents, . . . . . | .15 | .93  | 39.5 | 33.8 | 5.7  | 13.0 | 8.7  | 4.3  | 4.40 | 1.32 | .33 | .23 | .10 | 2.60 | 0 | 0 | 7,700,000  |
| Effluent of Tank 1, . . . . .       | .17 | 1.25 | 41.2 | 34.8 | 6.4  | 14.0 | 9.6  | 4.4  | 4.58 | 1.45 | .37 | .24 | .13 | 2.72 | 0 | 0 | 7,300,000  |
| " " 2, . . . . .                    | .15 | .67  | 40.8 | 35.1 | 5.7  | 13.8 | 8.7  | 5.1  | 4.42 | 1.37 | .34 | .24 | .10 | 2.64 | 0 | 0 | 6,900,000  |
| " " 3, . . . . .                    | .16 | 1.25 | 38.9 | 32.1 | 6.8  | 13.5 | 8.2  | 5.3  | 4.47 | 1.37 | .35 | .24 | .11 | 2.67 | 0 | 0 | 10,300,000 |
| " " 4, . . . . .                    | .13 | .56  | 37.0 | 33.2 | 3.8  | 10.6 | 8.2  | 2.3  | 4.13 | 1.10 | .28 | .20 | .06 | 2.33 | 0 | 0 | 6,200,000  |

*Period III. August 5 to September 1, 1893.*

|                                     |      |     |      |      |      |      |      |      |      |      |      |     |     |     |      |   |            |
|-------------------------------------|------|-----|------|------|------|------|------|------|------|------|------|-----|-----|-----|------|---|------------|
| Sewage, . . . . .                   | 22.5 | .67 | 1.10 | 60.0 | 38.5 | 21.5 | 30.7 | 13.3 | 17.4 | 5.55 | 2.81 | .85 | .34 | .51 | 3.52 | 0 | 4,500,000  |
| Average of all effluents, . . . . . | 22.1 | .15 | 1.00 | 46.9 | 39.5 | 7.4  | 16.5 | 11.7 | 4.8  | 5.14 | 1.54 | .46 | .32 | .14 | 3.56 | 0 | 11,500,000 |
| Effluent of Tank 1, . . . . .       | 22.1 | .18 | 1.30 | 49.5 | 39.9 | 9.6  | 18.3 | 11.9 | 6.4  | 5.31 | 1.90 | .50 | .38 | .17 | 3.67 | 0 | 9,400,000  |
| " " 2, . . . . .                    | 22.1 | .16 | .85  | 49.8 | 42.9 | 6.9  | 18.0 | 12.7 | 5.3  | 5.23 | 1.66 | .48 | .34 | .14 | 3.72 | 0 | 15,800,000 |
| " " 3, . . . . .                    | 22.1 | .16 | 1.20 | 48.6 | 40.8 | 7.8  | 17.6 | 12.0 | 5.6  | 5.36 | 1.63 | .50 | .35 | .15 | 3.86 | 0 | 8,600,000  |
| " " 4, . . . . .                    | 22.0 | .12 | .62  | 39.6 | 34.5 | 6.1  | 12.0 | 10.4 | 1.6  | 4.67 | 1.20 | .36 | .27 | .09 | 2.97 | 0 | 12,300,000 |

*Period IV. September 2 to September 29, 1893.*

|                                     |      |     |      |      |      |      |      |      |      |      |      |     |     |     |      |   |           |
|-------------------------------------|------|-----|------|------|------|------|------|------|------|------|------|-----|-----|-----|------|---|-----------|
| Sewage, . . . . .                   | 21.0 | .74 | 1.07 | 62.2 | 45.1 | 17.1 | 33.0 | 19.0 | 14.0 | 5.64 | 3.23 | .86 | .41 | .45 | 4.54 | 0 | 2,500,000 |
| Average of all effluents, . . . . . | 21.1 | .18 | .95  | 52.8 | 47.8 | 5.0  | 21.3 | 17.8 | 3.5  | 5.53 | 1.88 | .49 | .34 | .15 | 3.95 | 0 | 7,000,000 |
| Effluent of Tank 1, . . . . .       | 21.0 | .18 | 1.22 | 53.6 | 47.7 | 5.9  | 22.1 | 18.0 | 4.1  | 5.71 | 2.03 | .54 | .36 | .18 | 3.80 | 0 | 3,800,000 |
| " " 2, . . . . .                    | 21.1 | .17 | .70  | 52.7 | 49.5 | 3.2  | 20.7 | 17.6 | 3.1  | 5.83 | 1.77 | .46 | .31 | .15 | 4.16 | 0 | 9,500,000 |
| " " 3, . . . . .                    | 21.0 | .20 | 1.10 | 55.9 | 48.8 | 7.1  | 23.3 | 18.3 | 5.0  | 5.54 | 2.04 | .52 | .34 | .18 | 4.36 | 0 | 7,500,000 |
| " " 4, . . . . .                    | 21.1 | .16 | .77  | 49.2 | 45.1 | 4.1  | 19.1 | 17.4 | 1.7  | 5.53 | 1.60 | .43 | .35 | .08 | 3.43 | 0 | 7,200,000 |

*Period V. September 30 to October 27, 1893.*

|                                     |      |     |      |      |      |      |      |      |      |      |      |     |     |     |      |   |            |
|-------------------------------------|------|-----|------|------|------|------|------|------|------|------|------|-----|-----|-----|------|---|------------|
| Sewage, . . . . .                   | 15.5 | .75 | 1.12 | 64.0 | 46.9 | 17.1 | 34.6 | 19.7 | 14.9 | 5.81 | 3.64 | .90 | .49 | .41 | 4.87 | 0 | 2,220,000  |
| Average of all effluents, . . . . . | 15.5 | .19 | 1.00 | 54.1 | 48.4 | 5.7  | 21.8 | 18.3 | 3.5  | 6.11 | 2.12 | .61 | .45 | .16 | 4.11 | 0 | 5,900,000  |
| Effluent of Tank 1, . . . . .       | 15.5 | .20 | 1.22 | 56.2 | 49.0 | 7.2  | 23.9 | 19.4 | 4.5  | 6.14 | 2.27 | .64 | .47 | .17 | 3.47 | 0 | 3,600,000  |
| " " 2, . . . . .                    | 15.5 | .18 | .80  | 50.9 | 45.7 | 5.2  | 19.0 | 14.7 | 4.3  | 5.32 | 1.77 | .53 | .36 | .17 | 4.45 | 0 | 10,000,000 |
| " " 3, . . . . .                    | 15.5 | .19 | 1.02 | 55.6 | 49.7 | 5.9  | 22.0 | 18.3 | 3.7  | 6.57 | 2.34 | .67 | .47 | .10 | 4.71 | 0 | 6,800,000  |
| " " 4, . . . . .                    | 15.5 | .18 | .97  | 53.5 | 49.4 | 4.1  | 22.2 | 20.8 | 1.4  | 6.41 | 2.09 | .63 | .51 | .11 | 3.80 | 0 | 3,100,000  |

\* Determined after filtration through filter-paper.

One of the most striking features of these analyses is the excessive number of bacteria found in the effluents,—several times as many as in the crude sewage. The causes of this remarkable condition were investigated by Drs. Wilson and Agar of the United States Army Hospital. The results obtained show that, while the sewage contained a great variety of species of bacteria, the effluents contained only a few species in large numbers, and these forms were very much more abundant than in the crude sewage. It appears that the bulk of the bacteria of the sewage was taken to the bottoms of the tanks in the precipitate, and did not exist in the effluents. The tanks, however, served as a breeding place for enormous numbers of the species found in the effluents, which were, presumably, non-pathogenic, for, so far as we know, the pathogenic forms sometimes found in water are probably incapable of growing in the conditions present in the tanks. The treatment may be said to have secured a partial but probably very incomplete removal of objectionable bacteria.

#### THE WORK OF THE INDIVIDUAL TANKS.

The quantities of sewage treated and chemicals employed for each tank during the different periods and the costs of the chemicals are shown in the following tables :—

##### *Period I. June 10 to July 7, 1893.*

|           | Efficiency.                                                                              |                                                                  | DAILY QUANTITY OF<br>SEWAGE TREATED<br>IN ONE TANK. |          | FOR ONE MILLION GALLONS.   |                   |                      |                  |                                |
|-----------|------------------------------------------------------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------|----------|----------------------------|-------------------|----------------------|------------------|--------------------------------|
|           | Per Cent.<br>of Organic<br>Matter<br>Removed,<br>as shown<br>by<br>Chemical<br>Analysis. | Suspended<br>Matter<br>in Effluent.<br><br>Parts per<br>100,000. | THOUSANDS OF<br>GALLONS.                            |          | Cost of<br>Chem-<br>icals. | Lime.<br>Pounds.* | Copperas.<br>Pounds. | Alum.<br>Pounds. | Ferric<br>Sulphate.<br>Pounds. |
|           |                                                                                          |                                                                  | Average.                                            | Maximum. |                            |                   |                      |                  |                                |
| Tank 1, . | 53†                                                                                      | 5.7                                                              | 598                                                 | 806      | \$7 44                     | 752               | 615                  | -                | -                              |
| " 2, .    | 52†                                                                                      | 5.4                                                              | 598                                                 | 592      | 8 17                       | 412               | -                    | 623              | -                              |
| " 3, .    | Not in operation.                                                                        |                                                                  |                                                     |          |                            |                   |                      |                  |                                |
| " 4, .    | 60†                                                                                      | 2.8                                                              | 465                                                 | 642      | 10 30                      | 556               | -                    | 766              | -                              |

##### *Period II. July 8 to August 4, 1893.*

|           |     |     |     |     |        |     |     |     |   |
|-----------|-----|-----|-----|-----|--------|-----|-----|-----|---|
| Tank 1, . | 41† | 6.4 | 605 | 765 | \$5 79 | 744 | 376 | -   | - |
| " 2, .    | 45† | 5.7 | 598 | 749 | 7 40   | 435 | -   | 542 | - |
| " 3, .    | 44† | 6.8 | 604 | 786 | 8 21   | 731 | 755 | -   | - |
| " 4, .    | 55† | 3.8 | 454 | 612 | 9 20   | 626 | 363 | 896 | - |

\* When dolomite lime was employed only two-thirds of its weight is used in this table.

† The percentage purification indicated by these figures is too low, owing to the partial sedimentation of the sewage analyzed, already referred to on pages 602, 603. The efficiency of the plant as a whole is discussed beyond. The figures for each period, however, are comparable among themselves.

*Period III. August 5 to September 1, 1893.*

|           | Efficiency.<br>—<br>Per Cent<br>of Organic<br>Matter<br>Removed,<br>as shown<br>by<br>Chemical<br>Analysis. | Suspended<br>Matter<br>in Effluent<br>—<br>Parts per<br>100,000. | DAILY QUANTITY OF<br>SEWAGE TREATED<br>IN ONE TANK.<br>—<br>THOUSANDS OF<br>GALLONS. |          | FOR ONE MILLION GALLONS.   |                        |                           |                       |                                     |
|-----------|-------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|--------------------------------------------------------------------------------------|----------|----------------------------|------------------------|---------------------------|-----------------------|-------------------------------------|
|           |                                                                                                             |                                                                  | Average.                                                                             | Maximum. | Cost of<br>Chem-<br>icals. | Lime.<br>—<br>Pounds.* | Copperas.<br>—<br>Pounds. | Alum.<br>—<br>Pounds. | Ferric<br>Sulphate.<br>—<br>Pounds. |
|           |                                                                                                             |                                                                  |                                                                                      |          |                            |                        |                           |                       |                                     |
| Tank 1, . | 41†                                                                                                         | 9.6                                                              | 693                                                                                  | 860      | \$6 71                     | 1,033                  | 335                       | —                     | —                                   |
| " 2, .    | 43†                                                                                                         | 6.9                                                              | 690                                                                                  | 863      | 7 12                       | 496                    | —                         | 488                   | —                                   |
| " 3, .    | 42†                                                                                                         | 7.8                                                              | 693                                                                                  | 840      | 8 82                       | 1,003                  | 671                       | —                     | —                                   |
| " 4, .    | 58†                                                                                                         | 5.1                                                              | 449                                                                                  | 514      | 9 70                       | 1,079                  | 744                       | —                     | —                                   |

*Period IV. September 2 to September 29, 1893.*

|           |     |     |     |     |        |       |     |     |     |
|-----------|-----|-----|-----|-----|--------|-------|-----|-----|-----|
| Tank 1, . | 38† | 5.9 | 651 | 912 | \$7 03 | 1,000 | 391 | —   | —   |
| " 2, .    | 46† | 3.2 | 572 | 908 | 8 76   | 520   | —   | 645 | —   |
| " 3, .    | 39† | 7.1 | 665 | 942 | 8 64   | 854   | 857 | —   | 175 |
| " 4, .    | 51† | 4.1 | 565 | 770 | 11 16  | 1,278 | 820 | —   | —   |

*Period V. September 30 to October 27, 1893.*

|           |     |     |     |     |        |       |       |     |     |
|-----------|-----|-----|-----|-----|--------|-------|-------|-----|-----|
| Tank 1, . | 34† | 7.2 | 674 | 809 | \$6 70 | 1,050 | 504   | —   | —   |
| " 2, .    | 46† | 5.2 | 522 | 604 | 9 48   | 677   | —     | 723 | —   |
| " 3, .    | 31† | 5.9 | 666 | 828 | 9 18   | 793   | —     | —   | 417 |
| " 4, .    | 37† | 4.1 | 679 | 832 | 10 82  | 1,300 | 1,002 | —   | —   |

## CHARACTER OF THE SLUDGE.

The quantity of sludge pressed was estimated by weighing an occasional representative pressing. No separate record could be kept of the weights of sludge from the different tanks. Analyses of the pressed sludge were made from time to time. Its composition was quite constant, the average result being —

|                       |                |
|-----------------------|----------------|
| Moisture, . . . . .   | 58.0 per cent. |
| Dry matter, . . . . . | 42.0 "         |

## The dry matter contained —

|                                             |                |
|---------------------------------------------|----------------|
| Ash, . . . . .                              | 55.6 per cent. |
| Loss on ignition (in a radiator), . . . . . | 44.4 "         |
| Fats, . . . . .                             | 8.2 "          |

\* When dolomite lime was employed only two-thirds of its weight is used in this table.

† The percentage purification indicated by these figures is too low, owing to the partial sedimentation of the sewage analyzed, already referred to on pages 602, 603. The efficiency of the plant as a whole is discussed beyond. The figures for each period, however, are comparable among themselves.



During May and June occasional "soft" pressings were obtained, which decreased the percentage of dry matter in the total output. The presses were but rarely able to press the sludge promptly as produced, and on two occasions, July 13 and September 4 to 6, it was necessary to discharge unpressed sludge into the lake to avoid a nuisance at the works. There was also a slight accidental discharge in October. The sludge was usually pressed without the addition of lime. With copperas as a precipitant the addition of lime to the sludge had little effect upon the rapidity of pressing. With alum as a precipitant the addition of lime allowed somewhat more rapid work, but the same result was obtained by mixing the sludge from copperas with the alum sludge.

The quantities of sludge pressed in the different periods are shown in the following table. The table also includes estimates of the quantity of sludge on hand and of the quantity discharged into the lake reduced to the basis of pressed sludge cake. These estimates, based in part upon the observed heights of sludge in the tanks at different times, are necessarily only rough approximations.

*Summary of Sludge Statistics.*

[In tons of pressed sludge.]

| PERIOD—1892.         | Quantity of Sewage Treated.<br>—<br>Million Gallons. | Sludge Pressed. | Discharged into Lake Michigan. | Stock of Unpressed Sludge on hand at end of Period. | Quantity Precipitated during Period. | Per Cent. of Dry Matter in Sludge. | Tons Dry Matter in Sludge Precipitated. * | Sludge per Million Gallons Sewage. |
|----------------------|------------------------------------------------------|-----------------|--------------------------------|-----------------------------------------------------|--------------------------------------|------------------------------------|-------------------------------------------|------------------------------------|
| April 15 to June 9,  | 47                                                   | 85              | —                              | 10                                                  | 95                                   | 38                                 | 36.1                                      | 2.0                                |
| June 10 to July 7,   | 52                                                   | 140             | —                              | 35                                                  | 165                                  | 41                                 | 67.6                                      | 3.2                                |
| July 8 to Aug. 4,    | 63                                                   | 192             | 13                             | 10                                                  | 180                                  | 42                                 | 75.6                                      | 2.9                                |
| Aug. 5 to Sept. 1,   | 71                                                   | 250             | —                              | 45                                                  | 285                                  | 42                                 | 119.7                                     | 4.0                                |
| Sept. 2 to Sept. 29, | 69                                                   | 297             | 33                             | 10                                                  | 295                                  | 40                                 | 118.0                                     | 4.3                                |
| Sept. 30 to Oct. 27, | 71                                                   | 320             | 4                              | 30                                                  | 344                                  | 38                                 | 180.7                                     | 4.8                                |
| Totals and av'ges,   | 373                                                  | 1,284           | 50                             | 30                                                  | 1,304                                | 40                                 | 547.7                                     | 3.5                                |

**EFFICIENCY OF THE PROCESS.**

As stated above, it was found that large quantities of insoluble matters were removed from the sewage by sedimentation in the sewers between "blows," and when "blows" occurred these matters were washed out, so that the sewage at these times was often several times as concentrated as at other times. The concentrated sewage is not properly represented in the sewage samples taken for examina-

tion owing to the difficulty or impossibility of getting samples at these times; or, in case samples were taken, of determining what proportion of the daily flow was of the same character as the samples. For this reason the efficiency of the plant, as calculated from the chemical analyses, is considerably below the actual efficiency. We have, however, a fairly satisfactory record of the quantities of organic matters in the sludge and in the effluents, and by adding them together we can obtain an approximate estimate of the matters in the sewage, which is probably much more accurate under the circumstances than the direct calculation from the average analyses.

*Efficiency of Precipitation.*

[By four weeks' periods.]

| PERIOD.<br>1893.           | Average<br>Quantity of<br>Sewage<br>Treated<br>Daily.<br>—<br>Thousand<br>Gallons. | Tons<br>Organic<br>Matter in<br>the Sewage<br>Calculated<br>from<br>Analyses. | Tons<br>Organic<br>Matter in<br>the Effluent. | Tons<br>Organic<br>Matter in<br>the Sludge. | Sum Total<br>Organic<br>Matter in<br>the Sewage. | Corre-<br>sponding<br>Percentage<br>of Organic<br>Matter<br>Removed. |
|----------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|-----------------------------------------------|---------------------------------------------|--------------------------------------------------|----------------------------------------------------------------------|
| April 14 to June 9, . . .  | 830                                                                                | —                                                                             | —                                             | 16.2                                        | —                                                | —                                                                    |
| June 10 to July 7, . . .   | 1,866                                                                              | 62.9                                                                          | 28.5                                          | 30.4                                        | 58.9                                             | 52                                                                   |
| July 8 to Aug. 4, . . .    | 2,261                                                                              | 60.1                                                                          | 34.3                                          | 34.0                                        | 68.3                                             | 50                                                                   |
| Aug. 5 to Sept. 1, . . .   | 2,529                                                                              | 90.5                                                                          | 46.8                                          | 53.9                                        | 100.7                                            | 54                                                                   |
| Sept. 2 to Sept. 29, . . . | 2,453                                                                              | 94.6                                                                          | 61.1                                          | 53.1                                        | 114.2                                            | 46                                                                   |
| Sept. 30 to Oct. 27, . . . | 2,541                                                                              | 102.6                                                                         | 64.6                                          | 58.8                                        | 123.4                                            | 48                                                                   |
| Total, June 10 to Oct. 27, | 2,330                                                                              | 410.7                                                                         | 235.3                                         | 230.2                                       | 465.5                                            | 49                                                                   |

This calculation indicates that for the entire period the error in the average analyses of the sewage was 12 per cent., but that during the first part of the time, when "blows" were less frequent the error was less and for the last two months, with almost continual "blows," the error was greater.

The calculation shows that as a result of the operation of the works for the twenty weeks for which complete data are available, substantially one-half of the total organic matters of the sewage was removed by the precipitation. This efficiency is slightly less than was indicated for the Worcester plant by the examination of the Massachusetts State Board of Health in 1891,\* and is less than we

\* Annual Report, 1891, page 267. [During this examination, which was made for the week ending July 29, 1891, the average amount of organic matter removed from the Worcester sewage was 56 per cent. Since Mr. Hazen's paper was written, the annual report of the superintendent of sewers of the city of Worcester for 1893 has been issued, and extracts from it may be found on pages 343-345 of this volume. As there stated, the average amount of organic matter removed from the sewage from July 19 to Dec. 1, 1893, was about 50 per cent. ED.]

had hoped to obtain. The experiments made at Lawrence in 1889\* had indicated that chemical precipitation might remove as much as 60 per cent. of the total organic matter of the sewage.

The above calculation includes practically the whole operation of the plant, with all the conditions as they actually existed. Some of the unfavorable conditions which have been mentioned could hardly have been anticipated, and in a permanent plant would have been rectified; but there was no opportunity for changes in the short time that the plant was operated in Chicago. With the single exception of the test of the Worcester plant for one week, mentioned above, I do not know of any results which can be fairly compared with these, as it is manifestly unfair to compare the entire operation of one plant with a single set of analyses from another plant, taken, perhaps, under the most favorable conditions possible; and it must be admitted that our knowledge in regard to the total result of the operation of other chemical precipitation works is extremely limited.

The erroneous impression which may result from a single set of analyses was well illustrated by the analyses of sewage and of effluents from the Chicago works taken at noon, August 14, when the sewage had reached its full strength, but while the effluent was mainly from the diluted sewage of the preceding night. The results of these analyses indicated that 88 per cent. of the organic matters of the sewage had been removed, and were of course entirely misleading.

The disappointingly low efficiency of the plant is, I believe, to be attributed solely to the unfavorable conditions for sedimentation present in the tanks. The violent fluctuations in the flow, indeed, made it impossible to apply the chemicals to the sewage with that regularity which is necessary for the best results, and the agitation of the sewage in passing from the outlet of the sewer to the settling tanks was such that minute air-bubbles were constantly inclosed in the precipitate, often causing it to rise at first instead of sinking; but in spite of these minor difficulties I believe comparatively good results would have been obtained had better opportunities for sedimentation been present. This is strongly suggested by the record of Tank 4, which, during the first three periods, was protected from the excessive flows at the times of "blows" by sending the extra volume through

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\* Special Report of the Massachusetts State Board of Health on Purification of Sewage and Water, 1890.

the other tanks, and it so received a somewhat smaller and very much steadier flow. While the tank was so operated it constantly gave a very much better effluent than the other tanks, and for the whole period averaged a removal of 58 per cent. of the organic matters of the sewage passing through it at an average daily flow of 456,000 gallons, while all the other tanks for the same time removed only about 50 per cent. of the organic matters, with average flows of 635,000 gallons daily.

The prejudicial effect of these excessive flows for short periods is believed to be mainly due to the general stirring up which they gave to the contents of the tanks. They did not last long enough for any of the sewage coming in them to pass through the tanks before the ordinary rate was restored. The sloping surfaces of the bottoms of the tanks were always covered with more or less sludge, which was apparently to some extent loosened and mixed again with the sewage at these times, and did not again completely settle back, but was instead carried out by the effluent, reducing seriously the total efficiency.

It was shown by several series of chlorine determinations that the incoming sewage did not with any regularity displace the sewage previously in the tanks, but to a very large extent mixed with it, and a fraction of it appeared in the effluent almost at once, long before the displacement equalled the capacity of the tank. This tendency may have been increased by the irregularities of the flow, as it undoubtedly was by the variations in the temperature of the sewage. It was repeatedly observed that the turbidity of the effluents increased very much in the latter part of the afternoon, often being two or three times as great at five o'clock as at noon; and it was thought possible that the slightly increased temperature of the afternoon sewage might have caused it to come at once to the top and flow out, leaving the colder night and morning sewage in the tanks, or it may have been simply the effect of the continued higher flow during the hours in the middle of the day which brought this suspended matter to the top only after continuing for some hours.

The slowness with which the sludge was removed from the tanks undoubtedly contributed its share to the imperfect results, although it must be said that sludge was also present in Tank 4 when it was doing uniformly excellent work with a limited flow. The sludge which settled on the conical-shaped bottoms of the tanks did not of itself settle to the point of the cone, but required to be pushed down

at intervals of two or three days by a heavy weight which was pulled back by means of an attached rope. The fact that the lower plates overlapped the upper and were secured by a row of heavy projecting rivets, making ledges at every joint, may have had something to do with the failure of the sludge to slide. The filter presses, although their capacity was continually increased as improvements in details of construction and operation were effected, only removed the sludge so slowly that there was hardly a time during the whole operation of the plant when there was not sludge waiting to be pressed. At times the quantity so held became troublesome by decomposing, and on two occasions, as has already been stated, it was necessary to discharge some of it unpressed into the lake to avoid a nuisance at the works. There was always plenty of sludge on the bottoms and sides of the tanks to be washed out when the occasion was favorable.

#### SUMMARY.

In an experimental way the sewage cleansing works of the World's Columbian Exposition have served to indicate some of the peculiarities of the form of settling-tank used, and have clearly defined some forms of construction which should not be repeated.

In a practical way they succeeded in holding back from Lake Michigan thirteen hundred tons of sludge removed from the sewage treated, and containing two hundred and fifty tons of actual organic matters. They prevented the sewage from making a nuisance along the lake front such as often resulted from one of the city's sewers discharging untreated sewage just north of the grounds, and they reduced the danger of infection of the water drawn from the Hyde Park intake and supplied to the fair grounds and to the southern part of the city of Chicago.

As an object lesson to thousands of visitors they have given new ideas as to the possibility and necessity of sewage treatment and as to modern methods of securing the cleanliness of the waters on which many cities and towns are located.

## APPENDICES.

## APPENDIX I.

*Showing Daily Volume of Sewage in Thousands of Gallons.*

| DAY OF MONTH—1893.  | May.  | June.  | July.  | August. | September. | October. |
|---------------------|-------|--------|--------|---------|------------|----------|
| 1, . . . . .        | -     | 776    | 1,942  | 2,421   | 2,810      | 1,979    |
| 2, . . . . .        | -     | 1,104  | 1,789  | 2,255   | 2,891      | 2,359    |
| 3, . . . . .        | -     | 1,184  | 1,934  | 2,426   | 2,152      | 2,394    |
| 4, . . . . .        | -     | 1,244  | 2,472  | 2,388   | 2,581      | 2,639    |
| 5, . . . . .        | -     | 1,353  | 2,309  | 2,703   | 2,662      | 2,424    |
| 6, . . . . .        | -     | 1,338  | 2,255  | 1,099   | 2,910      | 2,477    |
| 7, . . . . .        | -     | 1,343  | 2,164  | 2,129   | 3,186      | 2,821    |
| 8, . . . . .        | -     | 1,626  | 2,211  | 2,261   | 3,116      | 1,852    |
| 9, . . . . .        | -     | 1,452  | 1,918  | 2,434   | 3,147      | 2,935    |
| 10, . . . . .       | -     | 1,477  | 2,150  | 2,362   | 1,890      | 2,650    |
| 11, . . . . .       | -     | 1,231  | 2,298  | 2,631   | 2,761      | 2,644    |
| 12, . . . . .       | -     | 1,401  | 2,239  | 2,734   | 2,738      | 2,955    |
| 13, . . . . .       | -     | 1,904  | 2,364  | 1,419   | 2,358      | 2,714    |
| 14, . . . . .       | -     | 1,728  | 2,337  | 2,376   | 2,803      | 2,473    |
| 15, . . . . .       | -     | 1,841  | 2,500  | 2,573   | 2,271      | 1,908    |
| 16, . . . . .       | -     | 1,789  | 1,871  | 2,886   | 2,395      | 2,540    |
| 17, . . . . .       | -     | 1,943  | 2,407  | 2,550   | 1,879      | 2,722    |
| 18, . . . . .       | 718   | 1,722  | 2,483  | 2,496   | 2,463      | 2,594    |
| 19, . . . . .       | 852   | 1,517  | 2,433  | 2,957   | 2,270      | 2,581    |
| 20, . . . . .       | 897   | 1,887  | 2,769  | 2,222   | 2,238      | 2,726    |
| 21, . . . . .       | 863   | 1,602  | 2,523  | 2,764   | 2,389      | 3,040    |
| 22, . . . . .       | 843   | 1,990  | 2,508  | 2,669   | 2,431      | 1,962    |
| 23, . . . . .       | 1,082 | 2,033  | 1,420  | 2,746   | 2,360      | 2,729    |
| 24, . . . . .       | 1,149 | 1,976  | 1,574  | 2,996   | 1,667      | 2,814    |
| 25, . . . . .       | 1,100 | 1,791  | 2,108  | 2,739   | 2,179      | 2,760    |
| 26, . . . . .       | 983   | 2,006  | 2,291  | 2,940   | 2,300      | 2,793    |
| 27, . . . . .       | 1,065 | 2,046  | 2,319  | 1,967   | 2,426      | 2,643    |
| 28, . . . . .       | 1,017 | 1,823  | 2,549  | 2,810   | 2,150      | 2,926    |
| 29, . . . . .       | 1,049 | 1,828  | 2,651  | 2,811   | 2,093      | 2,207    |
| 30, . . . . .       | 1,299 | 1,848  | 1,573  | 2,814   | 2,235      | 2,203    |
| 31, . . . . .       | 1,460 | -      | 2,022  | 2,825   | -          | 1,503    |
| Totals, . . . . .   | -     | 48,803 | 68,683 | 77,403  | 72,742     | 77,772   |
| Averages, . . . . . | -     | 1,627  | 2,216  | 2,497   | 2,425      | 2,509    |

## APPENDIX II.

*Showing Percentages of Total Daily Volume for the Different Hours of the Day.*

[illegible]

## APPENDIX III.

*Showing the Number of "Blows" on each Day. The actual Number of Blows is recorded, except that when they occurred at very frequent intervals for a Number of Hours in succession, the Number of Hours has been substituted for the Number of Blows.*

| DAY OF MONTH—1893. | April. | May. | June. | July. | August. | September. | October. |
|--------------------|--------|------|-------|-------|---------|------------|----------|
| 1, . . . . .       | -      | 5    | 2     | 0     | 4       | 4          | 3        |
| 2, . . . . .       | -      | 7    | 0     | 0     | 5       | 3          | 4        |
| 3, . . . . .       | -      | 1    | 0     | 3     | 1       | 2          | 12       |
| 4, . . . . .       | -      | 0    | 0     | 4     | 4       | 4          | 2        |
| 5, . . . . .       | -      | 3    | 0     | 1     | 5       | 0          | 1        |
| 6, . . . . .       | -      | 5    | 0     | 0     | 2       | 0          | 3        |
| 7, . . . . .       | -      | 10   | 0     | 0     | 0       | 4          | 4        |
| 8, . . . . .       | -      | 0    | 0     | 0     | 2       | 10         | 0        |
| 9, . . . . .       | -      | 0    | 1     | 0     | 1       | 20         | 4        |
| 10, . . . . .      | -      | 10   | 0     | 0     | 0       | 10         | 3        |
| 11, . . . . .      | -      | 0    | 1     | 0     | 1       | 8          | 6        |
| 12, . . . . .      | -      | 4    | 10    | 0     | 7       | 3          | 2        |
| 13, . . . . .      | -      | 5    | 10    | 0     | 6       | 6          | 0        |
| 14, . . . . .      | 1      | 1    | 0     | 2     | 0       | 7          | 0        |
| 15, . . . . .      | 2      | 10   | 0     | 2     | 4       | 6          | 0        |
| 16, . . . . .      | 1      | 9    | 0     | 2     | 10      | 4          | 4        |
| 17, . . . . .      | 5      | 7    | 1     | 0     | 4       | 0          | 12       |
| 18, . . . . .      | 3      | 5    | 3     | 2     | 0       | 2          | 16       |
| 19, . . . . .      | 8      | 10   | 0     | 4     | 2       | 0          | 9        |
| 20, . . . . .      | 5      | 10   | 4     | 1     | 0       | 1          | 11       |
| 21, . . . . .      | 2      | 3    | 10    | 0     | 0       | 0          | 3        |
| 22, . . . . .      | 1      | 1    | 5     | 2     | 7       | 3          | 5        |
| 23, . . . . .      | 0      | 0    | 0     | 0     | 0       | 0          | 6        |
| 24, . . . . .      | 0      | 0    | 1     | 0     | 0       | 0          | 15       |
| 25, . . . . .      | 0      | 0    | 0     | 0     | 0       | 8          | 13       |
| 26, . . . . .      | 0      | 5    | 0     | 2     | 4       | 8          | 5        |
| 27, . . . . .      | 2      | 3    | 0     | 5     | 2       | 2          | 0        |
| 28, . . . . .      | 9      | 5    | 4     | 0     | 3       | 8          | 7        |
| 29, . . . . .      | 10     | 3    | 6     | 10    | 0       | 10         | 8        |
| 30, . . . . .      | 6      | 0    | 0     | 1     | 0       | 0          | 11       |
| 31, . . . . .      | -      | 4    | -     | 3     | 0       | -          | 3        |



## APPENDIX IV.

*Showing Hourly Variation in Temperature of Sewage.*

[Average temperature (in Centigrade degrees) of sewage at the different hours of the day for periods of ten consecutive days.]

| Hour.                 | Sept. 15<br>to<br>Sept. 24,<br>1893. | Oct 1<br>to<br>Oct. 10,<br>1893. | Oct. 14<br>to<br>Oct. 23,<br>1893. | Average<br>20<br>Days. | Above<br>Minimum<br>Average. |
|-----------------------|--------------------------------------|----------------------------------|------------------------------------|------------------------|------------------------------|
| 12.30 A.M., . . . . . | 21.32                                | 17.28                            | 14.33                              | 17.64                  | 0.34                         |
| 1.30, . . . . .       | 21.06                                | 17.31                            | 14.24                              | 17.53                  | 0.23                         |
| 2.30, . . . . .       | 21.01                                | 17.21                            | 14.16                              | 17.46                  | 0.16                         |
| 3.30, . . . . .       | 21.10                                | 17.06                            | 14.09                              | 17.42                  | 0.12                         |
| 4.30, . . . . .       | 21.04                                | 16.90                            | 14.00                              | 17.31                  | 0.01                         |
| 5.30, . . . . .       | 21.18                                | 16.96                            | 13.91                              | 17.35                  | 0.06                         |
| 6.30, . . . . .       | 21.33                                | 16.86                            | 13.79                              | 17.34                  | 0.04                         |
| 7.30, . . . . .       | 20.89                                | 16.93                            | 14.08                              | 17.30                  | 0.00                         |
| 8.30, . . . . .       | 21.15                                | 17.16                            | 13.98                              | 17.43                  | 0.13                         |
| 9.30, . . . . .       | 21.17                                | 17.25                            | 14.43                              | 17.62                  | 0.22                         |
| 10.30, . . . . .      | 21.16                                | 17.43                            | 14.35                              | 17.65                  | 0.25                         |
| 11.30, . . . . .      | 21.33                                | 17.60                            | 14.75                              | 17.89                  | 0.59                         |
| 12.30 P.M., . . . . . | 21.27                                | 17.50                            | 14.60                              | 17.79                  | 0.49                         |
| 1.30, . . . . .       | 21.19                                | 17.63                            | 14.86                              | 17.89                  | 0.59                         |
| 2.30, . . . . .       | 21.22                                | 17.70                            | 14.73                              | 17.83                  | 0.53                         |
| 3.30, . . . . .       | 21.22                                | 17.66                            | 14.92                              | 17.93                  | 0.63                         |
| 4.30, . . . . .       | 21.33                                | 17.61                            | 14.70                              | 17.90                  | 0.60                         |
| 5.30, . . . . .       | 21.37                                | 17.64                            | 14.75                              | 17.92                  | 0.62                         |
| 6.30, . . . . .       | 21.44                                | 17.56                            | 14.40                              | 17.80                  | 0.50                         |
| 7.30, . . . . .       | 21.20                                | 17.38                            | 14.41                              | 17.66                  | 0.36                         |
| 8.30, . . . . .       | 21.25                                | 17.43                            | 14.39                              | 17.69                  | 0.39                         |
| 9.30, . . . . .       | 21.29                                | 17.54                            | 14.66                              | 17.83                  | 0.53                         |
| 10.30, . . . . .      | 21.21                                | 17.33                            | 14.52                              | 17.69                  | 0.39                         |
| 11.30, . . . . .      | 21.08                                | 17.31                            | 14.29                              | 17.56                  | 0.26                         |

## APPENDIX V.

*Showing Hourly Range in the Chlorine of the Sewage and Effluents.*

[Average chlorine in sewage or effluent at the different hours for four or five consecutive days.]

[Parts per 100,000.]

| HOURLY                                              | Sewage<br>May 9 to 13,<br>1893. | Sewage<br>May 30 to<br>June 2,<br>1893. | Effluent<br>Tank 2,<br>May 30 to<br>June 2,<br>1893. | Sewage<br>August 21 to<br>August 23,<br>1893. | Effluent<br>Tank 1,<br>August 21 to<br>August 23,<br>1893. |
|-----------------------------------------------------|---------------------------------|-----------------------------------------|------------------------------------------------------|-----------------------------------------------|------------------------------------------------------------|
| 12 P.M., . . . . .                                  | 4.04                            | 8.65                                    | 5.98                                                 | 3.42                                          | 7.34                                                       |
| 3 A.M., . . . . .                                   | 1.73                            | 5.87                                    | 6.04                                                 | 1.27                                          | 6.36                                                       |
| 6 " . . . . .                                       | 1.28                            | 3.37                                    | 6.10                                                 | 0.85                                          | 5.19                                                       |
| 8 " . . . . .                                       | 0.83                            | -                                       | -                                                    | 2.47                                          | 4.69                                                       |
| 9 " . . . . .                                       | 0.95                            | 0.97                                    | 5.93                                                 | 4.80                                          | 4.11                                                       |
| 10 " . . . . .                                      | 0.95                            | 1.36                                    | 5.90                                                 | 5.56                                          | 3.95                                                       |
| 11 " . . . . .                                      | 1.27                            | 2.91                                    | 5.53                                                 | 6.18                                          | 4.11                                                       |
| 12 M., . . . . .                                    | 2.24                            | 7.75                                    | 5.35                                                 | 7.13                                          | 4.18                                                       |
| 1 P.M., . . . . .                                   | 2.63                            | 7.28                                    | 5.23                                                 | 5.29                                          | 5.01                                                       |
| 2 " . . . . .                                       | 3.70                            | 8.60                                    | 5.32                                                 | 7.74                                          | 4.46                                                       |
| 3 " . . . . .                                       | 4.85                            | 7.69                                    | 5.39                                                 | 7.16                                          | 5.17                                                       |
| 4 " . . . . .                                       | 5.51                            | 9.24                                    | 5.47                                                 | 7.24                                          | 5.68                                                       |
| 5 " . . . . .                                       | 5.55                            | 7.89                                    | 5.57                                                 | 7.96                                          | 6.57                                                       |
| 6 " . . . . .                                       | 6.26                            | 7.87                                    | 5.66                                                 | 7.45                                          | 7.14                                                       |
| 9 " . . . . .                                       | 4.90                            | 9.36                                    | 5.97                                                 | 8.42                                          | 7.89                                                       |
| 12 " . . . . .                                      | 4.04                            | 8.65                                    | 5.98                                                 | 3.42                                          | 7.76                                                       |
| Average daily flow of sewage estimated at . . . . . | 750,000                         | 1,160,000                               |                                                      | 2,794,000                                     |                                                            |

It is seen that with the low flow in May the day sewage was being slowly forced out of the sewers all through the night. During the forenoon nothing but slightly dirty water was received, and at about noon the morning sewage first made its appearance at the works. In August, with three times as great a flow, the morning sewage was noticeable as early as eight o'clock, and at nine it had become quite concentrated. Afterward it slowly increased in strength until nine in the evening, after which the sewage was rapidly displaced by clear water, and from midnight until morning very little sewage matter was received.

## APPENDIX VI.

*Samples of Sewage and Effluent taken at Noon when the Sewage had reached its full Concentration and while the Effluent was derived from the Dilute Sewage of the Preceding Night.*

[Parts per 100,000.]

|           | Tempera-<br>ture.<br>—<br>Degrees<br>Centi-<br>grade. | APPEAR-<br>ANCE. |        | RESIDUE ON EVAPORATION. |             |            |                      |             |            | Chlorine. | Oxygen Consumed. | NITROGEN AS             |             |            |               |           |           |
|-----------|-------------------------------------------------------|------------------|--------|-------------------------|-------------|------------|----------------------|-------------|------------|-----------|------------------|-------------------------|-------------|------------|---------------|-----------|-----------|
|           |                                                       | Turbidity.       | Color. | TOTAL RESIDUE.          |             |            | LOSS ON<br>IGNITION. |             |            |           |                  | ALBUMINOID.<br>AMMONIA. |             |            | Free Ammonia. | Nitrites. | Nitrates. |
|           |                                                       |                  |        | Total.                  | Dissolved.* | Suspended. | Total.               | Dissolved.* | Suspended. |           |                  | Total.                  | Dissolved.* | Suspended. |               |           |           |
|           |                                                       |                  |        |                         |             |            |                      |             |            |           |                  |                         |             |            |               |           |           |
| Sewage,   | 22.5                                                  | .70              | 1.20   | 84.2                    | 55.0        | 29.2       | 50.0                 | 26.6        | 23.4       | 6.42      | 3.52             | 1.00                    | .39         | .61        | 4.60          | 0         | 0         |
| Effluent, | 21.5                                                  | .05              | 0.20   | 22.4                    | 21.4        | 1.0        | 7.6                  | 6.8         | 0.8        | 2.03      | 0.35             | 0.14                    | .14         | .00        | 1.10          | 0         | 0         |

\* Determined after filtration through filter-paper.

## APPENDIX VII.

*Showing Monthly Attendance at the Fair in comparison with the Volume of Sewage produced.\**

| MONTH—1893.             | Sewage.<br>—<br>Thousands<br>of<br>Gallons. | APPROXIMATE ATTENDANCE IN THOUSANDS. |                              |          |                      | Sewage<br>per<br>Admission.<br>—<br>Gallons. | Sewage per<br>Admission<br>and 30<br>Per Cent. for<br>Midway Plaisance. |
|-------------------------|---------------------------------------------|--------------------------------------|------------------------------|----------|----------------------|----------------------------------------------|-------------------------------------------------------------------------|
|                         |                                             | Paid<br>Admissions.                  | Photo-<br>graphic<br>Passes. | Workmen. | Total<br>Attendance. |                                              |                                                                         |
| May, . . .              | 29,709†                                     | 1,050                                | 486                          | 465      | 1,981                | 15.0                                         | 19.5                                                                    |
| June, . . .             | 48,803                                      | 2,675                                | 900                          | 300      | 3,875                | 12.5                                         | 16.3                                                                    |
| July, . . .             | 68,683                                      | 2,762                                | 1,216                        | 100      | 4,078                | 16.9                                         | 22.0                                                                    |
| August, . . .           | 77,403                                      | 3,515                                | 1,172                        | —        | 4,687                | 16.5                                         | 21.4                                                                    |
| September, . .          | 72,742                                      | 4,659                                | 1,150                        | —        | 5,809                | 12.5                                         | 16.3                                                                    |
| October, . . .          | 77,772                                      | 6,866                                | 1,168                        | —        | 8,034                | 9.7                                          | 12.6                                                                    |
| Totals and<br>Averages, | 375,112                                     | 21,527                               | 6,072                        | 865      | 28,464               | 13.2                                         | 17.2                                                                    |

\* The sewage received at the cleansing works was from Jackson Park only, the Midway Plaisance draining into city sewers, and, as the attendance included both Jackson Park and the Plaisance, it is necessary for this calculation to estimate the quantity of sewage produced in the Plaisance.

† Estimated.

## APPENDIX VIII.

*Showing the Quantities of Various Substances and the Number of Bacteria in the Sewage for Each Person admitted to the Fair Grounds.*

| MONTH — 1893. | Sewage<br>per Person.<br>Gallons. | Sewage<br>per Person.<br>Liters. | Chlorine<br>per Person.<br>Grams. | Nitrogen in<br>Free<br>Ammonia<br>per Person.<br>Grams. | Nitrogen in<br>Albuminoid<br>Ammonia<br>per Person.<br>Grams. | Total<br>Nitrogen<br>per Person.<br>Grams. | Bacteria in<br>Billions<br>per Person. |
|---------------|-----------------------------------|----------------------------------|-----------------------------------|---------------------------------------------------------|---------------------------------------------------------------|--------------------------------------------|----------------------------------------|
| June, . .     | 16.3                              | 62                               | 3.68                              | 2.06                                                    | .51                                                           | 3.07                                       | 290                                    |
| July, . .     | 22.0                              | 84                               | 4.20                              | 2.42                                                    | .53                                                           | 3.48                                       | 284                                    |
| August, . .   | 21.4                              | 81                               | 4.40                              | 2.71                                                    | .63                                                           | 3.97                                       | 356                                    |
| September, .  | 16.3                              | 62                               | 3.49                              | 3.00                                                    | .53                                                           | 4.06                                       | 155                                    |
| October, . .  | 12.6                              | 48                               | 2.78                              | 2.33                                                    | .43                                                           | 3.19                                       | 106                                    |
| Averages, .   | 17.7                              | 67                               | 3.71                              | 2.60                                                    | .53                                                           | 3.56                                       | 232                                    |

## APPENDIX IX.

*Showing Quantity, Composition and Cost of Chemicals used in Precipitation.\**

## I. SULPHATE OF ALUMINA.

[From ROBERT STEVENSON & Co., Chicago.]

Cost, in barrels, . . . . . \$47 00 a ton.

*Analysis.*

Insoluble in water, . . . . . .06 per cent.  
 Alumina, . . . . . 15.64 "  
 Ferric oxide, . . . . . .50 "  
 Sulphuric acid, . . . . . 34.88 "  
 Moisture and undetermined, . . . . . 48.92 "

## II. SULPHATE OF ALUMINA.

[From MERRIMAC CHEMICAL COMPANY, Boston.]

Cost, in bulk, . . . . . \$20 40 a ton.

*Analysis.*

Insoluble in water, . . . . . 6.11 per cent.  
 Alumina, . . . . . 13.17 "  
 Ferric oxide, . . . . . 1.31 "  
 Sulphuric acid, . . . . . 32.66 "  
 Moisture and undetermined, . . . . . 46.75 "

Taking into account the difference in analyses the first sample was twice as expensive as the second.

\* The cost includes freight to Jackson Park in each case.

## III. COPPERAS.

[From WASHBURN &amp; MOEN, Waukegan, Ill.]

Cost, in bulk, . . . . . \$13 40 a ton.

*Analysis.*

|                                      |                |
|--------------------------------------|----------------|
| Insoluble in water, . . . . .        | 0.24 per cent. |
| Ferrous oxide, . . . . .             | 25.21 "        |
| Sulphuric acid, . . . . .            | 28.50 "        |
| Moisture and undetermined, . . . . . | 46.05 "        |

## IV. CRUDE FERRIC SULPHATE.

[From JOBBINS &amp; VAN RYNEBECKE, Aurora, Ill.]

Cost, in barrels, . . . . . \$32 00 a ton.

*Analysis.*

|                                      |                 |
|--------------------------------------|-----------------|
| Insoluble in water, . . . . .        | 12.00 per cent. |
| Ferric oxide, . . . . .              | 22.76 "         |
| Sulphuric acid, . . . . .            | 45.00 "         |
| Moisture and undetermined, . . . . . | 20.24 "         |

## V. LIME.

[From CHICAGO UNION LIME COMPANY]

Cost, in barrels, \$0.60 a barrel of 200 pounds, . . . \$6 00 a ton.

*Analysis.*

|                                                  |                |
|--------------------------------------------------|----------------|
| Insoluble in acid, . . . . .                     | 0.10 per cent. |
| Alumina and ferric oxide, . . . . .              | 1.00 "         |
| Calcium oxide, . . . . .                         | 57.10 "        |
| Magnesium oxide, . . . . .                       | 38.60 "        |
| Water, carbonic acid and undetermined, . . . . . | 3.20 "         |
| Lime soluble in water, . . . . .                 | 55.01 "        |

## VI. LIME.

[From HANNIBAL LIME Co., Hannibal, Mo.]

Cost, in barrels, \$0.75 a barrel of about 170 pounds, . . \$8 80 a ton.

Cost, in bulk, \$0.22 a bushel, . . . . . 6 50 "

*Analysis.*

|                                                  |                |
|--------------------------------------------------|----------------|
| Alumina and ferric oxide, . . . . .              | 1.50 per cent. |
| Calcium oxide, . . . . .                         | 95.00 "        |
| Water, carbonic acid and undetermined, . . . . . | 3.50 "         |
| Lime soluble in water, . . . . .                 | 93.00 "        |

Even at the higher price paid for the Hannibal lime it was a much more economical lime to use on account of the much higher percentage of available lime. The magnesia present in the local lime is without value in sewage treatment; it simply adds itself to the sludge.

During the first weeks an attempt was made to apply chemicals in proportion to the flow of sewage without having any fixed schedule, but the plan proved to be too complicated, with the four sets of chemicals for the four tanks, each of which required separate regulation, particularly during those hours when it was impracticable for either myself or my assistant to closely supervise the operation, and after a little while the following arrangement was made and worked very satisfactorily: a schedule was prepared showing the quantity of alum, copperas, or ferric sulphate to be dissolved for each tank at 7.30 A.M., 3.30 and 11.30 P.M. The men on each shift commenced work half an hour earlier than these times. Each man weighed the quantities of chemicals shown by the schedule into the respective tanks used for this purpose and dissolved them in a tank full of water, using at first steam, and in the summer after the water became warmer, compressed air to thoroughly stir up the contents of the tanks. The solutions so prepared were allowed to flow into the sewage, varying the rates with changes in the flow of sewage as well as possible, but in such a way as to make the solution last through and yet be exhausted at the expiration of the eight hours' shift. The lime schedule was arranged somewhat differently. The lime was always slaked in barrel lots, and the schedule showed the hours at which lime was to be added. Each lot was made to last until the next lot was slaked, varying the flow with the flow of sewage as far as possible within that time.

A constant stream of water was kept running through the lime box in use to stir up and wash out the lime as required. Water from a tap instead of sewage was used both for this purpose and for dissolving the other chemicals, on account of the practical difficulty of regulating a small stream of sewage with the slight head available. Putting the chemicals into the sewage at four points instead of one, so reduced the quantity and the flow of water required to carry the chemicals at each point, that when sewage was used for mixing the chemicals the gates were continually becoming stopped with sewage matters. The quantity of water used for dissolving the alum, copperas and ferric sulphate was about six thousand gallons daily; the quantity used for carrying the lime may be roughly estimated at from twenty to forty thousand gallons.

The schedules of chemicals were arranged to make the quantities employed on the different shifts approximately proportional to the quantities of sewage, some allowance being made, however, for the

more dilute sewage during the night. Usually the same quantities of chemicals were used through one week, except that as a rule only half as large a quantity was required on Sunday, while on special days the quantities were increased. With copperas, as much lime was ordinarily used as would give a strong reaction with phenolphthalein in the effluent. With ferric sulphate and alum the quantity of lime used was less and was added more to give a sludge which could be easily pressed than with reference to the effluent, as sewage is sufficiently alkaline to decompose these salts without the use of lime.

Variations in the quantities of sewage necessitated very frequent changes in the chemical schedules, and the proportions of the total quantities used on the different shifts were also varied to meet changing conditions. In calculating the cost of chemicals the weights in the note books have been taken, and these weights in all cases foot up somewhat differently from the weights bought, the error usually being under 3 per cent., sometimes in one direction, sometimes in the other. During the first part of the time when Alum, I. and Lime, V. were being used, the costs were very much higher than for corresponding quantities of Alum, II. and Lime, VI. During two weeks, one ending July 14 and the other September 8, the amount of lime used was limited by the stock on hand.

*Quantities in Pounds of Various Chemicals Employed (by Weeks).*

| WEEK ENDING—<br>1893. | Sewage.<br>—<br>Thousands<br>of Gals. | Alum,<br>I. | Alum,<br>II. | Copperas,<br>III. | Ferric<br>Sulphate,<br>IV. | Lime,<br>V. | Lime,<br>VI. | Total<br>Cost. | Cost per<br>Million<br>Gallons. |
|-----------------------|---------------------------------------|-------------|--------------|-------------------|----------------------------|-------------|--------------|----------------|---------------------------------|
| April 21, . . .       | 2,000*                                | 2,000       | —            | —                 | —                          | —           | —            | \$47 00        | —                               |
| April 28, . . .       | 3,000*                                | 2,728       | —            | —                 | —                          | 770         | —            | 60 52          | —                               |
| May 5, . . .          | 6,000*                                | 4,531       | —            | —                 | —                          | —           | —            | 106 47         | —                               |
| May 12, . . .         | 6,000*                                | 5,131       | —            | —                 | —                          | —           | —            | 120 57         | —                               |
| May 19, . . .         | 6,800*                                | 5,630       | —            | 390               | —                          | 1,031       | —            | 134 91         | —                               |
| May 26, . . .         | 6,919                                 | 4,950       | —            | 1,650             | —                          | 4,808       | —            | 141 80         | \$20 40                         |
| June 2, . . .         | 7,770                                 | 1,860       | 3,140        | 1,750             | —                          | 7,891       | —            | 111 13         | 14 30                           |
| June 9, . . .         | 9,540                                 | 2,658       | 2,400        | 2,030             | —                          | 6,729       | —            | 120 72         | 12 65                           |
| June 16, . . .        | 11,371                                | —           | 4,900        | 2,450             | —                          | 8,015       | —            | 90 44          | 7 95                            |
| June 21, . . .        | 12,694                                | —           | 5,460        | 2,880             | —                          | 2,357       | 5,430        | 106 06         | 8 35                            |
| June 30, . . .        | 13,318                                | —           | 5,130        | 4,120             | —                          | —           | 8,776        | 118 18         | 8 87                            |
| July 7, . . .         | 14,865                                | —           | 5,020        | 5,080             | —                          | —           | 9,983        | 127 99         | 8 61                            |
| July 14, . . .        | 15,517                                | —           | 4,795        | 4,815             | —                          | —           | 2,785        | 93 16          | 6 00                            |
| July 21, . . .        | 16,986                                | —           | 4,900        | 5,040             | —                          | —           | 11,110       | 130 25         | 7 66                            |
| July 28, . . .        | 15,099                                | —           | 2,170        | 6,870             | —                          | —           | 11,963       | 121 16         | 8 04                            |
| Aug. 4, . . .         | 15,736                                | —           | 2,250        | 7,020             | —                          | —           | 14,258       | 132 98         | 8 45                            |
| Aug. 11, . . .        | 15,619                                | —           | 2,170        | 6,885             | —                          | —           | 13,538       | 128 26         | 8 21                            |
| Aug. 18, . . .        | 17,034                                | —           | 2,210        | 7,020             | —                          | —           | 15,365       | 137 07         | 8 05                            |
| Aug. 25, . . .        | 19,093                                | —           | 2,440        | 7,380             | —                          | —           | 16,841       | 148 59         | 7 78                            |
| Sept. 1, . . .        | 18,977                                | —           | 2,610        | 7,620             | —                          | —           | 17,068       | 148 18         | 7 81                            |
| Sept. 8, . . .        | 19,498                                | —           | 2,535        | 7,410             | —                          | 8,279       | —            | 98 34          | 5 04                            |
| Sept. 15, . . .       | 17,968                                | —           | 2,600        | 7,935             | —                          | 969         | 18,208       | 165 08         | 9 18                            |
| Sept. 22, . . .       | 16,056                                | —           | 2,600        | 4,874             | 1,624                      | —           | 18,637       | 167 66         | 10 44                           |
| Sept. 29, . . .       | 15,176                                | —           | 2,610        | 6,525             | 1,630                      | —           | 17,742       | 172 92         | 11 39                           |
| Oct. 6, . . .         | 16,507                                | —           | 2,400        | 6,825             | 1,625                      | —           | 17,463       | 150 10         | 9 09                            |
| Oct. 13, . . .        | 18,071                                | —           | 2,865        | 7,800             | 2,185                      | —           | 18,393       | 173 09         | 9 58                            |
| Oct. 20, . . .        | 17,849                                | —           | 2,600        | 6,825             | 1,950                      | —           | 16,701       | 157 35         | 8 81                            |
| Oct. 27, . . .        | 18,741                                | —           | 2,710        | 7,110             | 2,030                      | —           | 16,680       | 161 66         | 8 62                            |

\* Estimated.

## APPENDIX X.

*Distribution of Mineral Matters.*

The following table contains calculations of the quantities of mineral matters in the sewage, chemicals employed, sludge and effluent for the different periods. Without discussing in detail the method of calculation, it may be stated that it is estimated that each hundred pounds of lime employed adds one hundred and seventy pounds to the mineral matters of either the sludge or of the effluents, and that one hundred pounds of the other chemicals add fifty-three pounds in the same way.

|                                                     | June 10<br>to<br>July 7. | July 8<br>to<br>Aug. 4. | Aug. 5<br>to<br>Sept. 1. | Sept. 2<br>to<br>Sept. 29. | Sept. 30<br>to<br>Oct. 27. | Total. |
|-----------------------------------------------------|--------------------------|-------------------------|--------------------------|----------------------------|----------------------------|--------|
| Tons of lime used, . . . . .                        | 15.5                     | 20.0                    | 31.4                     | 30.4                       | 34.6                       | 132.0  |
| Tons of other chemicals, . . . . .                  | 17.5                     | 18.9                    | 19.2                     | 18.5                       | 23.5                       | 97.6   |
| Lime $\times 1.70$ , . . . . .                      | 26.4                     | 34.1                    | 53.4                     | 51.6                       | 58.9                       | 224.4  |
| Other chemicals $\times 0.53$ , . . . . .           | 9.3                      | 10.0                    | 10.1                     | 9.9                        | 12.4                       | 51.7   |
| Sum, . . . . .                                      | 35.7                     | 44.1                    | 63.5                     | 61.5                       | 71.3                       | 276.1  |
| Mineral matter in sewage (tons), . . . . .          | 64.0                     | 64.9                    | 86.3                     | 83.7                       | 87.5                       | 386.4  |
| Sum, . . . . .                                      | 99.7                     | 109.0                   | 149.8                    | 155.2                      | 158.8                      | 602.5  |
| Mineral matter in sludge, . . . . .                 | 37.2                     | 41.6                    | 65.8                     | 64.9                       | 71.9                       | 281.4  |
| Mineral matter in effluent, . . . . .               | 64.4                     | 69.9                    | 89.6                     | 90.3                       | 95.8                       | 410.0  |
| Sum, . . . . .                                      | 101.6                    | 111.5                   | 145.4                    | 155.2                      | 167.7                      | 601.4  |
| Excess of matters in effluent and sludge, . . . . . | 1.9                      | 2.5                     | 5.6                      | 10.0                       | 8.9                        | 28.9   |

The excess of mineral matters in the sludge and effluent is to be attributed to the same causes as the excess of organic matters, but the discrepancy is less, owing to the small quantity of insoluble mineral matters in the sewage.



## APPENDIX XI.

*Cost of Construction and of Operation of Sewage Cleansing Works.*

The cost of construction of the sewage cleansing works was about \$55,000, of which more than \$20,000 was for the building. The approximate costs of operation for different periods are shown in the following table, in which the expenses are distributed as well as possible between the treatment of the sewage and the pressing of the sludge. The figures do not include the cost of superintendence, the cost of the chemical laboratory, or the cost of burning the sludge, which was done at an Engle crematory.

|                                 | April 14<br>to<br>June 9. | June 10<br>to<br>July 7. | July 8<br>to<br>Aug. 4. | Aug. 5<br>to<br>Sept. 1. | Sept. 2<br>to<br>Sept. 29. | Sept. 30<br>to<br>Oct. 27. | Total<br>April 14<br>to<br>Oct. 27. |
|---------------------------------|---------------------------|--------------------------|-------------------------|--------------------------|----------------------------|----------------------------|-------------------------------------|
| Cost of chemicals, . . . .      | \$840                     | \$442                    | \$477                   | \$562                    | \$604                      | \$642                      | \$3,567                             |
| Labor applying chemicals, .     | 215                       | 261                      | 217                     | 217                      | 217                        | 230                        | 1,357                               |
| Total cost of precipitation,    | \$1,055                   | \$703                    | \$694                   | \$779                    | \$821                      | \$872                      | \$4,924                             |
| Cost of fuel oil, . . . .       | 659                       | 412                      | 423                     | 373                      | 414                        | 331                        | 2,612                               |
| Labor on engine and presses,    | 1,590                     | 1,021                    | 1,018                   | 1,022                    | 962                        | 1,068                      | 6,671                               |
| Total cost of pressing, .       | \$2,249                   | \$1,433                  | \$1,441                 | \$1,395                  | \$1,376                    | \$1,399                    | \$9,283                             |
| Total cost of operation, .      | 3,304                     | 2,136                    | 2,136                   | 2,174                    | 2,197                      | 2,261                      | 14,207                              |
| Million gallons sewage treated, | 47                        | 52                       | 63                      | 71                       | 69                         | 71                         | 373                                 |
| Tons sludge cake pressed, .     | 85                        | 140                      | 192                     | 250                      | 297                        | 320                        | 1,284                               |

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# MORTALITY REPORTS.

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## SUMMARY OF THE WEEKLY MORTALITY REPORTS FROM CITIES AND TOWNS.

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This summary comprises the returns of deaths made at the end of each week by the town clerks, city registrars and other officials having in charge the vital statistics of cities and towns.

These returns are compiled each week and published as a bulletin, one copy of which is sent to each city and town in the State.

These reports are necessarily incomplete since they are voluntary, and comprise the mortality statistics of a part of the population only, the reporting places being chiefly the cities and large towns.

The estimated population of the cities and towns contributing to the returns of 1893 was about 1,460,000, or about 60 per cent. of the total population of the State.

The data embraced in this summary are the following : —

- Average height of barometer for each week.
- Mean or daily maximum temperature.
- Mean or daily minimum temperature.
- Rainfall expressed in inches.
- Total deaths reported for each week.
- Deaths of children under five years.
- Deaths from infectious diseases.
- Deaths from consumption.
- Deaths from acute lung diseases.
- Deaths from typhoid fever.
- Deaths from diarrhoeal diseases.
- Deaths from scarlet-fever.
- Deaths from measles.
- Deaths from diphtheria and croup.
- Deaths from puerperal fever.
- Deaths from whooping-cough.
- Deaths from malarial fever.
- Deaths from small-pox.
- Deaths from erysipelas.

Summary.

| DATE.    | Barometer. | Max im um Ther-<br>mometer. Mean<br>for each Week. | Min im um Ther-<br>mometer. Mean<br>for each Week. | Rain. Inches.* | Humidity. Mean<br>for each Week. | Total Deaths. | Deaths under Five. | Consumption. | Acute Lung<br>Diseases. | Typhoid Fever. | Diarrhoeal Diseases. | Scarlet-fever. | Measles. | Diphtheria<br>and Croup. | Whooping-cough. | Malaria Fever. | Small-pox. | Erysipelas. |
|----------|------------|----------------------------------------------------|----------------------------------------------------|----------------|----------------------------------|---------------|--------------------|--------------|-------------------------|----------------|----------------------|----------------|----------|--------------------------|-----------------|----------------|------------|-------------|
| Jan. 7.  | 29.66      | 31                                                 | 18                                                 |                | 68                               | 594           | 180                | 79           | 110                     | 16             | 6                    | 33             | 25       | 25                       | 1               |                |            | 1           |
| 14.      | 29.65      | 21                                                 | 4                                                  |                | 69                               | 573           | 174                | 65           | 115                     | 6              | 7                    | 21             | 32       | 32                       |                 |                |            | 1           |
| 21.      | 30.01      | 21                                                 | 7                                                  |                | 73                               | 591           | 162                | 74           | 124                     | 10             | 6                    | 20             | 22       | 22                       |                 |                |            | 1           |
| 28.      | 30.28      | 24                                                 | 20                                                 | 2.54           | 73                               | 540           | 165                | 63           | 117                     | 6              | 5                    | 12             | 22       | 22                       |                 |                |            | 1           |
| Feb. 4.  | 30.28      | 34                                                 | 20                                                 |                | 72                               | 524           | 165                | 53           | 122                     | 9              | 6                    | 10             | 23       | 23                       |                 |                |            | 1           |
| 11.      | 30.31      | 38                                                 | 17                                                 |                | 70                               | 597           | 193                | 42           | 140                     | 8              | 3                    | 14             | 15       | 15                       |                 |                |            | 1           |
| 18.      | 30.09      | 37                                                 | 26                                                 |                | 71                               | 630           | 231                | 78           | 133                     | 7              | 6                    | 10             | 27       | 27                       |                 |                |            | 1           |
| 25.      | 29.46      | 33                                                 | 14                                                 | 4.05           | 59                               | 614           | 195                | 64           | 112                     | 10             | 8                    | 13             | 21       | 21                       |                 |                |            | 1           |
| March 4. | 29.43      | 35                                                 | 23                                                 |                | 68                               | 569           | 193                | 77           | 107                     | 6              | 3                    | 10             | 22       | 22                       |                 |                |            | 1           |
| 11.      | 29.95      | 38                                                 | 27                                                 |                | 72                               | 624           | 196                | 66           | 130                     | 6              | 6                    | 4              | 16       | 16                       |                 |                |            | 1           |
| 18.      | 29.44      | 42                                                 | 26                                                 |                | 68                               | 638           | 211                | 62           | 132                     | 3              | 6                    | 21             | 20       | 20                       |                 |                |            | 1           |
| 25.      | 30.19      | 43                                                 | 29                                                 | 3.33           | 78                               | 653           | 201                | 79           | 126                     | 3              | 8                    | 12             | 25       | 25                       |                 |                |            | 1           |
| April 1. | 30.11      | 43                                                 | 31                                                 |                | 63                               | 609           | 163                | 64           | 140                     | 7              | 13                   | 10             | 16       | 16                       |                 |                |            | 1           |
| 8.       | 30.11      | 48                                                 | 32                                                 |                | 65                               | 637           | 165                | 83           | 148                     | 7              | 6                    | 10             | 13       | 13                       |                 |                |            | 1           |
| 15.      | 30.08      | 52                                                 | 39                                                 |                | 66                               | 671           | 199                | 97           | 166                     | 5              | 9                    | 11             | 14       | 14                       |                 |                |            | 1           |
| 22.      | 30.00      | 48                                                 | 37                                                 |                | 72                               | 625           | 189                | 63           | 170                     | 12             | 8                    | 12             | 17       | 17                       |                 |                |            | 1           |
| 29.      | 30.09      | 56                                                 | 40                                                 | 3.19           | 69                               | 580           | 177                | 61           | 146                     | 3              | 7                    | 13             | 20       | 20                       |                 |                |            | 1           |
| May 6.   | 29.92      | 53                                                 | 43                                                 |                | 85                               | 638           | 190                | 72           | 144                     | 3              | 7                    | 9              | 20       | 20                       |                 |                |            | 1           |
| 13.      | 30.09      | 67                                                 | 49                                                 |                | 62                               | 638           | 179                | 62           | 139                     | 6              | 6                    | 7              | 16       | 16                       |                 |                |            | 1           |
| 20.      | 29.68      | 62                                                 | 47                                                 |                | 84                               | 569           | 177                | 62           | 118                     | 8              | 4                    | 14             | 18       | 18                       |                 |                |            | 1           |
| 27.      | 27.87      | 74                                                 | 55                                                 | 5.32           | 61                               | 535           | 168                | 56           | 91                      | 6              | 6                    | 8              | 14       | 14                       |                 |                |            | 1           |
| June 3.  | 30.01      | 66                                                 | 51                                                 |                | 76                               | 479           | 147                | 57           | 72                      | 7              | 7                    | 15             | 13       | 13                       |                 |                |            | 1           |
| 10.      | 30.03      | 80                                                 | 61                                                 |                | 71                               | 545           | 175                | 59           | 70                      | 7              | 15                   | 10             | 14       | 14                       |                 |                |            | 1           |
| 17.      | 30.05      | 70                                                 | 59                                                 |                | 89                               | 465           | 145                | 57           | 64                      | 6              | 6                    | 11             | 13       | 13                       |                 |                |            | 1           |
| 24.      | 29.89      | 72                                                 | 54                                                 | 2.72           | 84                               | 427           | 123                | 39           | 62                      | 6              | 23                   | 8              | 12       | 12                       |                 |                |            | 1           |
| July 1.  | 30.04      | 67                                                 | 54                                                 |                | 88                               | 442           | 130                | 68           | 49                      | 6              | 6                    | 8              | 12       | 12                       |                 |                |            | 1           |
| 8.       | 29.82      | 80                                                 | 62                                                 |                | 70                               | 444           | 143                | 56           | 42                      | 4              | 23                   | 8              | 13       | 13                       |                 |                |            | 1           |
| 15.      | 29.82      | 69                                                 | 62                                                 |                | 61                               | 518           | 237                | 51           | 39                      | 4              | 94                   | 6              | 11       | 11                       |                 |                |            | 1           |
| 22.      | 29.90      | 86                                                 | 66                                                 |                | 64                               | 549           | 310                | 51           | 31                      | 6              | 176                  | 9              | 12       | 12                       |                 |                |            | 1           |
| 29.      | 29.89      | 70                                                 | 61                                                 | 2.27           | 69                               | 788           | 404                | 51           | 38                      | 6              | 234                  | 8              | 16       | 16                       |                 |                |            | 1           |
| Aug. 5.  | 29.99      | 78                                                 | 63                                                 |                | 76                               | 775           | 368                | 58           | 37                      | 4              | 245                  | 5              | 10       | 10                       |                 |                |            | 1           |
| 12.      | 29.95      | 81                                                 | 63                                                 |                | 76                               | 715           | 385                | 66           | 24                      | 4              | 242                  | 6              | 14       | 14                       |                 |                |            | 1           |
| 19.      | 29.94      | 71                                                 | 58                                                 |                | 68                               | 718           | 444                | 60           | 33                      | 15             | 213                  | 4              | 7        | 7                        |                 |                |            | 1           |
| 26.      | 29.99      | 77                                                 | 63                                                 | 5.22           | 81                               | 626           | 310                | 69           | 24                      | 11             | 167                  | 8              | 13       | 13                       |                 |                |            | 1           |

[illegible]

**Average reporting population,**

\* The figures in this column are the monthly averages for New England, being the mean of about 155 stations.

**1,458,840**

## TOTAL DEATHS.

The whole number of deaths reported for the year 1893 from the cities and towns contributing to these reports was 30,247, and the average number per week was 582. The greatest number of deaths reported in a single week was 788 in the week ending July 29, and the least number was 427 in the week ending June 24.

The weekly average number of deaths reported for each month was as follows:—

|                     |     |                      |     |
|---------------------|-----|----------------------|-----|
| January, . . . . .  | 576 | July, . . . . .      | 568 |
| February, . . . . . | 591 | August, . . . . .    | 708 |
| March, . . . . .    | 621 | September, . . . . . | 574 |
| April, . . . . .    | 622 | October, . . . . .   | 534 |
| May, . . . . .      | 595 | November, . . . . .  | 496 |
| June, . . . . .     | 479 | December, . . . . .  | 563 |

The months in which the greatest mortality was reported were March, April and August, and those in which there was the least reported mortality were June, October and November. The percentages of mortality in each of the four quarters of the year were as follows:—

|                           | ALL AGES. |              | AGES UNDER FIVE YEARS. |              |
|---------------------------|-----------|--------------|------------------------|--------------|
|                           | Numbers.  | Percentages. | Numbers.               | Percentages. |
| First quarter, . . . . .  | 7,153     | 23.65        | 2,276                  | 21.15        |
| Second quarter, . . . . . | 7,418     | 24.52        | 2,188                  | 20.34        |
| Third quarter, . . . . .  | 8,641     | 28.57        | 4,126                  | 38.35        |
| Fourth quarter, . . . . . | 7,035     | 23.26        | 2,169                  | 20.16        |
|                           | 30,247    | 100.00       | 10,759                 | 100.00       |

The death rate of reporting cities and towns was 20.74 per 1,000, the estimated population being 1,458,840.

## DEATHS UNDER FIVE YEARS.

The reported number of deaths of children under five years of age was 10,759, and the average weekly number was 207.

The greatest number reported in one week was 444 in the week ending August 19, and the least number was 123 in the week ending June 24. The ratio of the deaths of this class to the total reported mortality was 35.5 per cent., which was slightly greater than that of the preceding year (34.1 per cent.).

The average weekly number of deaths of children under five years of age by months was as follows : —

|                     |     |                      |     |
|---------------------|-----|----------------------|-----|
| January, . . . . .  | 170 | July, . . . . .      | 243 |
| February, . . . . . | 196 | August, . . . . .    | 377 |
| March, . . . . .    | 203 | September, . . . . . | 281 |
| April, . . . . .    | 177 | October, . . . . .   | 183 |
| May, . . . . .      | 178 | November, . . . . .  | 158 |
| June, . . . . .     | 148 | December, . . . . .  | 161 |

The months having the greatest number of deaths of this class were July, August and September, and those having the least number were June, November and December.

#### CONSUMPTION.

The number of reported deaths from consumption was 3,217 and the weekly average was 62. The greatest number of deaths reported from this cause in a single week was 97 in the week ending April 15, and the least number was 39 in the week ending June 24.

The average weekly number of reported deaths from this cause in each month was as follows : —

|                     |    |                      |    |
|---------------------|----|----------------------|----|
| January, . . . . .  | 70 | July, . . . . .      | 55 |
| February, . . . . . | 59 | August, . . . . .    | 61 |
| March, . . . . .    | 71 | September, . . . . . | 61 |
| April, . . . . .    | 75 | October, . . . . .   | 52 |
| May, . . . . .      | 63 | November, . . . . .  | 64 |
| June, . . . . .     | 53 | December, . . . . .  | 56 |

The months having the greatest number of deaths from this cause were March and April, and those having the least number were June and October.

The following table presents the variations from the weekly average number of deaths from this cause for the past four years : —

|                     | 1890. | 1891. | 1892. | 1893. |                      | 1890. | 1891. | 1892. | 1893. |
|---------------------|-------|-------|-------|-------|----------------------|-------|-------|-------|-------|
| January, . . . . .  | +42   | +4    | +13   | +8    | July, . . . . .      | -8    | -4    | -3    | -7    |
| February, . . . . . | +3    | -4    | -8    | -3    | August, . . . . .    | -4    | -3    | -4    | -1    |
| March, . . . . .    | +3    | -5    | -1    | +9    | September, . . . . . | -5    | -3    | -11   | -1    |
| April, . . . . .    | +1    | +4    | +7    | +13   | October, . . . . .   | -11   | +3    | -5    | -10   |
| May, . . . . .      | +1    | +6    | 0     | +1    | November, . . . . .  | -12   | -4    | -4    | +2    |
| June, . . . . .     | -3    | -2    | -5    | -9    | December, . . . . .  | 0     | +5    | -1    | -6    |



The ratio of reported deaths from consumption to the mortality reported from all causes was 106.35 per 1,000, while that of previous years was as follows:—

|                 |       |                 |       |
|-----------------|-------|-----------------|-------|
| 1886, . . . . . | 156.5 | 1890, . . . . . | 130.0 |
| 1887, . . . . . | 141.1 | 1891, . . . . . | 116.5 |
| 1888, . . . . . | 134.2 | 1892, . . . . . | 111.3 |
| 1889, . . . . . | 125.0 | 1893, . . . . . | 106.5 |

The ratio to the reporting population in 1893 was 2.20 per 1,000, as compared with 2.35 in 1892.

### ACUTE LUNG DISEASES.

The number of reported deaths from acute lung diseases (bronchitis, pneumonia, pleurisy and asthma) during the year was 4,484, and the weekly average was 86. The greatest number of deaths reported from this group of causes in a single week was 170, in the week ending April 22, and the least number 20, in the week ending September 9.

The average weekly number of reported deaths from these causes for each month was as follows:—

|                     |     |                      |     |
|---------------------|-----|----------------------|-----|
| January, . . . . .  | 116 | July, . . . . .      | 54  |
| February, . . . . . | 127 | August, . . . . .    | 29  |
| March, . . . . .    | 124 | September, . . . . . | 31  |
| April, . . . . .    | 154 | October, . . . . .   | 40  |
| May, . . . . .      | 123 | November, . . . . .  | 64  |
| June, . . . . .     | 67  | December, . . . . .  | 119 |

The months having the greatest number of reported deaths from these causes were February and April, and those having the least number were August and September.

The ratio of reported deaths from acute lung diseases to the reported mortality from all causes was 14.82 per 1,000.

The estimated death rate per 1,000 of the reporting population from these causes was 3.07, as compared with 2.82 for the previous year.

### TYPHOID FEVER.

The total number of reported deaths from this cause in 1893 was 427, and the average weekly number was 8. The greatest number reported in any single week from this cause was 19 in the week ending October 21, and the least number was 2 in the week ending April 1.

The average weekly number of deaths reported from this cause for each month was as follows :—

|                     |   |                      |    |
|---------------------|---|----------------------|----|
| January, . . . . .  | 9 | July, . . . . .      | 4  |
| February, . . . . . | 8 | August, . . . . .    | 9  |
| March, . . . . .    | 5 | September, . . . . . | 13 |
| April, . . . . .    | 6 | October, . . . . .   | 17 |
| May, . . . . .      | 5 | November, . . . . .  | 11 |
| June, . . . . .     | 5 | December, . . . . .  | 10 |

The months having the least number of deaths from this cause were March, June and July, and those having the greatest number were September, October and December.

The ratio of reported deaths from typhoid fever to the reported mortality from all causes was 14.12 per 1,000, and the ratio to the reporting population was .29, as compared with .31 in the previous year.

#### DIPHTHERIA AND CROUP.

The total number of reported deaths from diphtheria and croup in 1893 was 1,013, and the average number in each week was 20. The greatest number reported in a single week from these combined causes was 37, in the week ending October 28, and the least number was 6, in the week ending June 24.

The average weekly number of reported deaths from these causes for each month was as follows :—

|                     |    |                      |    |
|---------------------|----|----------------------|----|
| January, . . . . .  | 28 | July, . . . . .      | 16 |
| February, . . . . . | 22 | August, . . . . .    | 10 |
| March, . . . . .    | 21 | September, . . . . . | 15 |
| April, . . . . .    | 16 | October, . . . . .   | 29 |
| May, . . . . .      | 27 | November, . . . . .  | 26 |
| June, . . . . .     | 12 | December, . . . . .  | 27 |

The months having the greatest number of reported deaths from these causes were January, October and December, and those having the least number were June, August and September. The ratio of deaths from diphtheria and croup to the reported mortality from all causes was 33.49 per 1,000, and the death rate of the reporting population was .69 per 1,000, that of the previous year being .66.

## SCARLET-FEVER.

The reported deaths from scarlet-fever in 1893 were 527, and the average weekly number was 10. The greatest number of reported deaths from this cause in a single week was 21, in the week ending March 18, and the least number reported in a single week was 3, in the week ending September 9. The average weekly number reported in each month was as follows:—

|                     |    |                      |    |
|---------------------|----|----------------------|----|
| January, . . . . .  | 16 | July, . . . . .      | 7  |
| February, . . . . . | 12 | August, . . . . .    | 4  |
| March, . . . . .    | 15 | September, . . . . . | 5  |
| April, . . . . .    | 12 | October, . . . . .   | 5  |
| May, . . . . .      | 11 | November, . . . . .  | 9  |
| June, . . . . .     | 8  | December, . . . . .  | 13 |

The months having the greatest number of deaths from this cause were January and March, and those having the least number were August and October.

The ratio of deaths from this cause to the reported deaths from all causes was 17.44 per 1,000, and the death rate of the reporting population from this cause was .36 per 1,000, that of the previous year being .32.

## MEASLES.

The total number of reported deaths from measles in 1893 was 100, and the weekly average number was 2.

The greatest number in a single week was 9. There were nine weeks in which no deaths from measles were reported.

The average weekly number reported in each month was as follows:—

|                     |   |                      |   |
|---------------------|---|----------------------|---|
| January, . . . . .  | 1 | July, . . . . .      | 1 |
| February, . . . . . | 1 | August, . . . . .    | 1 |
| March, . . . . .    | 2 | September, . . . . . | 1 |
| April, . . . . .    | 2 | October, . . . . .   | 1 |
| May, . . . . .      | 7 | November, . . . . .  | 2 |
| June, . . . . .     | 3 | December, . . . . .  | 1 |

The ratio of deaths to the reported mortality from all causes was 3.31 per 1,000, and the death rate from this cause was .06 per 1,000 of the reported living population, as compared with .03 in 1892.

## DIARRHŒAL DISEASES.

The diseases included in this group are diarrhœa, dysentery, cholera morbus and cholera infantum.

From these causes combined the number of deaths reported in 1893 was 2,497, and the weekly average number was 48. The greatest number reported in a single week was 245 in the week ending August 5, and there were none reported in the week ending June 3.

The average weekly number of reported deaths from these causes in each month was as follows : —

|                     |    |                      |     |
|---------------------|----|----------------------|-----|
| January, . . . . .  | 6  | July, . . . . .      | 112 |
| February, . . . . . | 6  | August, . . . . .    | 217 |
| March, . . . . .    | 5  | September, . . . . . | 124 |
| April, . . . . .    | 8  | October, . . . . .   | 41  |
| May, . . . . .      | 6  | November, . . . . .  | 13  |
| June, . . . . .     | 12 | December, . . . . .  | 7   |

The months having the greatest number of reported deaths from these causes in 1893 were July, August and September, and those having the least were January, February and March.

The deaths from these causes in the third quarter of the year constituted 82 per cent. of the number of deaths from the same causes for the entire year. The ratio of reported deaths to the reported mortality for all causes was 82.5 per 1,000, and the death rate of the reporting population from these causes was 1.71 per 1,000, as compared with 1.66 in 1892.

### WHOOPIING-COUGH, MALARIAL FEVER, ERYSIPELAS, PUERPERAL FEVER AND SMALL-POX.

The essential statistics relating to these five diseases are embraced in the following table : —

|                            | Total Deaths<br>Reported. | Weekly<br>Average. | Ratio per<br>1,000<br>of Reported<br>Deaths from<br>All Causes. | Ratio per<br>1,000<br>of Estimated<br>Population. |
|----------------------------|---------------------------|--------------------|-----------------------------------------------------------------|---------------------------------------------------|
| Whooping-cough, . . . . .  | 119                       | 2.0                | 3.93                                                            | .08                                               |
| Erysipelas, . . . . .      | 94                        | 1.8                | 3.11                                                            | .06                                               |
| Puerperal fever, . . . . . | 48                        | .9                 | 1.58                                                            | .03                                               |
| Malarial fever, . . . . .  | 12                        | .2                 | .40                                                             | .008                                              |
| Small-pox, . . . . .       | 5                         | .1                 | .16                                                             | .003                                              |



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## REPORTS OF INFECTIOUS DISEASES.

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# REPORTS OF INFECTIOUS DISEASES.

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## REPORTS OF INFECTIOUS DISEASES.

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For very many years laws have existed in this State requiring that notices of cases of diseases dangerous to the public health should be given to the board of health of the city or town in which they have occurred; but the vital importance of such a system of notification does not appear to have become impressed firmly upon the public mind until a comparatively recent period. It was not until 1889, in fact, that a law was enacted in England requiring such notices, and even then it was made a matter of local option except in London.

The chief advantages of a system of notification lie in the possibility which is thus given to a local board of health to determine the extent of prevalence of an epidemic or a localized outbreak, and to inquire into the local causes which have operated to produce it. The board can then act intelligently in applying the proper remedies for preventing its further spread.

In Massachusetts there can be no doubt that the law relative to notification has been productive of excellent results in the prevention of disease, especially in the cities and large towns. It has furnished the local boards of health with the necessary information relative to the origin of outbreaks of infectious disease, and in many instances enabled them to take timely steps for preventing further outbreaks. The recent law requiring local boards to keep records upon this important matter, has furnished information as to the prevalence of certain diseases in the principal cities and towns of the State. In the smaller towns it is probable that instances of failure to comply with the provisions of the statute are much more frequent than they are in cities.

Up to 1883 no definite authority was given by statute for notification to the central authority, the State Board of Health. In that year a law was enacted requiring immediate notice to be given by local boards to the State Board of Health of the occurrence of cases of small-pox.

Ten years later by the provisions of chapter 302 of the Acts of 1893, it was required that reports of all diseases dangerous to the public health should be made to the State Board of Health.

The following is the act of 1893 relative to reporting dangerous diseases to the State Board of Health:—

[CHAPTER 302 OF THE ACTS OF 1893.]

(1.) When the board of health of any city or town has had notice of the occurrence of a case of small-pox or any other disease dangerous to the public health in such city or town, such board of health shall, within twenty-four hours after the receipt of such notice, notify the state board of health of the same.

(2.) If the board of health of the city or town, in which a case of small-pox or any other disease dangerous to the public health has occurred, refuses or neglects to send a notice as required in section one, such city or town shall forfeit its claim upon the Commonwealth for the payment of any expenses which may be incurred as provided in section eighty-three of chapter eighty of the Public Statutes.

Since no definite statement was made in this act defining the term “dangerous to the public health” the Board deemed it proper, in order to relieve local authorities of uncertainty in the matter, to specify the diseases which, in the opinion of the Board, should be thus reported under the provisions of the act.

For this purpose a circular was prepared in which it was specified that, in addition to *small-pox*, the following diseases shall be considered as dangerous to the public health within the meaning of the foregoing act: *scarlet-fever, measles, typhoid fever, diphtheria, membranous croup, cholera, yellow fever, typhus fever, cerebro-spinal meningitis, hydrophobia, malignant pustule, leprosy and trichinosis.*

This circular was issued in September, 1893. Previous to that date very few returns had been received in compliance with the terms of the act.

The act was approved May 3, 1893, and the first returns to be received came from the city of Cambridge, which has sent continuous returns since May, 1893. A few more cities and towns complied with the provisions of the act during the months of June, July and August, but no large number of cities and towns made returns until a circular was prepared notifying them of the enactment of the law. This circular was issued to each city and town in

September, after which the returns came with regularity from many cities and towns.

The following is the form of the return recommended by the Board and issued by it in the form of postal cards to each local Board of Health : —

*Report of Infectious Diseases to the State Board of Health, as  
required by the provisions of Chapter 302, Acts of 1893.*

|                                                                                                                                                              |                                     |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
| _____189                                                                                                                                                     |                                     |
| Cases of disease, dangerous to the public health, reported within the past<br>twenty-four hours to the Board of Health of the TOWN of _____<br>CITY of _____ |                                     |
| Small-pox, . . . . .                                                                                                                                         | Number of Cases of<br>each disease. |
| Scarlet-fever, . . . . .                                                                                                                                     |                                     |
| Diphtheria, . . . . .                                                                                                                                        |                                     |
| Membranous Croup, . . . . .                                                                                                                                  |                                     |
| Measles, . . . . .                                                                                                                                           |                                     |
| Typhoid Fever, . . . . .                                                                                                                                     |                                     |
| _____                                                                                                                                                        |                                     |
| _____                                                                                                                                                        |                                     |
| _____                                                                                                                                                        |                                     |
| _____                                                                                                                                                        |                                     |
| _____                                                                                                                                                        |                                     |

(Signed) \_\_\_\_\_  
Secretary or Agent of Board of Health.

*This postal card report should in all cases be signed by the Secretary or Clerk of the local Board of Health, or by the authorized Agent of the Board.  
In the blank spaces should be written the names of any of the unusual forms of infectious diseases enumerated below, if such should occur : —  
Cholera, Typhus Fever, Yellow Fever, Cerebro-spinal Meningitis, Hydrophobia, Malignant Pustule, Glanders and Trichinosis.*

The results of these notices are published each week in the Weekly Bulletin of Mortality and Infectious Diseases.

The following tables embrace the results of these returns for the fractional part of the year 1893 which elapsed after the enactment of the law : —

*Cases of Diseases dangerous to the Public Health reported by Local Boards of Health to the State Board of Health for the Fractional Year ending Dec. 31, 1893.*

|                                                                             |             |
|-----------------------------------------------------------------------------|-------------|
| Total number of reported cases of diphtheria and croup, . . . . .           | 1,109       |
| Total number of reported cases of scarlet-fever, . . . . .                  | 2,914       |
| Total number of reported cases of typhoid fever, . . . . .                  | 1,525       |
| Total number of reported cases of measles, . . . . .                        | 1,503       |
| Total number of reported cases of small-pox, . . . . .                      | 35          |
|                                                                             | <hr/> 7,086 |
| Additional cases of small-pox reported under the statute of 1883, . . . . . | 8           |
|                                                                             | <hr/> 7,094 |
| Total, . . . . .                                                            | 7,094       |

The following table shows the distribution of these cases by months of the year.

Reports were not generally forwarded to the State Board until after the public notice was given in September, which accounts for the small number before that date.

*Reports of Dangerous Diseases Classified by Months.*

| 1893.                | Diphtheria<br>and Croup. | Scarlet-<br>fever. | Typhoid<br>Fever. | Measles. | Small-pox. |
|----------------------|--------------------------|--------------------|-------------------|----------|------------|
| May, . . . . .       | 4                        | 33                 | 4                 | 43       | -          |
| June, . . . . .      | 4                        | 41                 | 2                 | 226      | 1          |
| July, . . . . .      | 10                       | 23                 | 5                 | 3        | -          |
| August, . . . . .    | 14                       | 28                 | 23                | 5        | -          |
| September, . . . . . | 191                      | 453                | 541               | 79       | 2          |
| October, . . . . .   | 316                      | 670                | 493               | 201      | 2          |
| November, . . . . .  | 305                      | 870                | 283               | 399      | 8          |
| December, . . . . .  | 265                      | 796                | 174               | 557      | 22         |
| Totals, . . . . .    | 1,109                    | 2,914              | 1,525             | 1,503    | 35         |

The following table presents the names of the reporting cities and towns with the number of cases of each disease reported by the local boards of health : —

*Cases of Infectious Diseases reported to the State Board of Health from One Hundred and Seventy-five Cities and Towns during 1893.*

|                 | Diphtheria<br>and Croup. | Scarlet-fever. | Typhoid<br>Fever. | Measles. | Small-pox. |                 | Diphtheria<br>and Croup. | Scarlet-fever. | Typhoid<br>Fever. | Measles. | Small-pox. |
|-----------------|--------------------------|----------------|-------------------|----------|------------|-----------------|--------------------------|----------------|-------------------|----------|------------|
| Acushnet, . .   | -                        | -              | 1                 | -        | -          | Dalton, . .     | -                        | 1              | -                 | -        | -          |
| Agawam, . .     | -                        | 1              | -                 | -        | -          | Danvers, . .    | -                        | 2              | 2                 | -        | -          |
| Amesbury, . .   | 7                        | 82             | 13                | -        | -          | Dedham, . .     | 1                        | 28             | 6                 | -        | -          |
| Amherst, . .    | -                        | -              | 1                 | -        | -          | Dighton, . .    | 1                        | 4              | 2                 | -        | -          |
| Arlington, . .  | 15                       | -              | 2                 | -        | -          | Douglas, . .    | 2                        | -              | -                 | -        | -          |
| Ashburnham, .   | -                        | 1              | -                 | -        | -          | Dover, . .      | 2                        | -              | -                 | -        | -          |
| Ashland, . .    | -                        | 1              | -                 | -        | -          | Dracut, . .     | -                        | 2              | -                 | -        | -          |
| Athol, . .      | -                        | 4              | 8                 | -        | -          | Easthampton, .  | 1                        | 1              | -                 | -        | -          |
| Attleborough, . | 7                        | -              | 5                 | 1        | -          | Edgartown, . .  | -                        | 4              | -                 | -        | -          |
| Auburn, . .     | -                        | -              | 1                 | -        | -          | Egremont, . .   | -                        | 1              | -                 | -        | -          |
| Ayer, . .       | -                        | 30             | 3                 | -        | -          | Erving, . .     | 1                        | 5              | 2                 | -        | -          |
| Bedford, . .    | 2                        | -              | -                 | -        | -          | Essex, . .      | 1                        | -              | -                 | -        | -          |
| Belmont, . .    | 1                        | 2              | 1                 | -        | -          | EVERETT, . .    | -                        | 34             | 8                 | 5        | -          |
| Berlin, . .     | -                        | 1              | -                 | -        | -          | FALL RIVER, . . | 12                       | 52             | 37                | 3        | -          |
| Beverly, . .    | 1                        | 5              | 8                 | -        | -          | FITCHBURG, . .  | 1                        | 7              | 10                | 3        | -          |
| Bolton, . .     | -                        | 2              | -                 | -        | -          | Foxborough, . . | -                        | 3              | -                 | -        | -          |
| BOSTON, . .     | 520                      | 816            | 445               | 161      | 27         | Franklin, . .   | -                        | 2              | 11                | -        | -          |
| Bourne, . .     | 1                        | -              | -                 | -        | -          | Gardner, . .    | -                        | 1              | 17                | -        | -          |
| Bradford, . .   | 5                        | 1              | 2                 | -        | -          | GLOUCESTER, . . | 5                        | 6              | 6                 | -        | -          |
| Brewster, . .   | -                        | -              | -                 | 1        | -          | Grafton, . .    | -                        | -              | 1                 | 2        | -          |
| Bridgewater, .  | -                        | -              | 1                 | -        | -          | Greenfield, . . | 3                        | -              | 1                 | -        | -          |
| Brimfield, . .  | -                        | -              | 1                 | -        | -          | Groton, . .     | -                        | 2              | 1                 | -        | -          |
| BROCKTON, . .   | 5                        | 28             | 16                | -        | -          | Halifax, . .    | -                        | 1              | -                 | -        | -          |
| Brookfield, . . | -                        | 1              | -                 | -        | -          | Hampden, . .    | 8                        | -              | -                 | -        | -          |
| Brookline, . .  | 1                        | 7              | 5                 | 2        | 1          | Hanson, . .     | 1                        | 5              | -                 | -        | -          |
| CAMBRIDGE, . .  | 52                       | 467            | 70                | 70       | -          | Hardwick, . .   | 5                        | 17             | -                 | -        | -          |
| Carlisle, . .   | -                        | 5              | -                 | -        | -          | Hatfield, . .   | -                        | 1              | -                 | -        | -          |
| Chelmsford, . . | -                        | -              | 2                 | -        | -          | HAVERHILL, . .  | 5                        | 19             | 31                | 1        | -          |
| CHELSEA, . .    | 10                       | 27             | 12                | -        | -          | Hingham, . .    | -                        | 2              | -                 | -        | -          |
| Cheshire, . .   | 11                       | -              | -                 | 1        | -          | Hinsdale, . .   | -                        | -              | 1                 | 9        | -          |
| Chesterfield, . | -                        | -              | 1                 | 16       | -          | Hull, . .       | 1                        | 1              | 1                 | -        | -          |
| CHICOPEE, . .   | 1                        | -              | 7                 | 1        | -          | Huntington, . . | -                        | 6              | 6                 | -        | -          |
| Concord, . .    | 3                        | 8              | 3                 | -        | -          | Ipswich, . .    | 3                        | 18             | 3                 | 2        | -          |
| Conway, . .     | -                        | -              | 1                 | -        | -          | Kingston, . .   | -                        | -              | 3                 | -        | -          |
| Cottage City, . | -                        | 5              | 1                 | -        | -          | Lancaster, . .  | -                        | -              | 2                 | -        | -          |

*Cases of Infectious Diseases, etc. — Continued.*

|                   | Diphtheria<br>and Croup. | Scarlet-fever. | Typhoid<br>Fever. | Measles. | Small-pox. |                | Diphtheria<br>and Croup. | Scarlet-fever. | Typhoid<br>Fever. | Measles. | Small-pox. |
|-------------------|--------------------------|----------------|-------------------|----------|------------|----------------|--------------------------|----------------|-------------------|----------|------------|
| LAWRENCE, .       | 16                       | 52             | 24                | 4        | -          | Norwood, .     | 1                        | 23             | -                 | -        | -          |
| Leicester, .      | 2                        | -              | 2                 | 1        | -          | Oakham, .      | -                        | -              | -                 | 8        | -          |
| Leominster, .     | 4                        | 4              | 5                 | 1        | -          | Orange, .      | -                        | 1              | 7                 | 2        | -          |
| Lexington, .      | -                        | -              | 1                 | -        | -          | Oxford, .      | -                        | -              | 3                 | -        | -          |
| Lincoln, .        | -                        | 2              | -                 | -        | -          | Palmer, .      | -                        | 2              | -                 | -        | -          |
| Littleton, .      | -                        | 4              | -                 | -        | -          | Paxton, .      | -                        | -              | 1                 | -        | -          |
| LOWELL, .         | 22                       | 66             | 37                | 6        | 1          | Peabody, .     | 2                        | 3              | 2                 | -        | -          |
| Ludlow, .         | -                        | 1              | -                 | -        | -          | Pembroke, .    | -                        | -              | 1                 | -        | -          |
| Lunenburg, .      | -                        | -              | -                 | 1        | -          | Pepperell, .   | -                        | 2              | 3                 | -        | 1          |
| LYNN, .           | 25                       | 130            | 53                | 3        | -          | PITTSFIELD, .  | 2                        | 44             | 17                | 65       | -          |
| MALDEN, .         | 5                        | 48             | 17                | 91       | -          | Plymouth, .    | 27                       | 3              | 8                 | 27       | -          |
| Mansfield, .      | 1                        | 15             | 1                 | -        | -          | QUINCY, .      | 2                        | 22             | 23                | 2        | -          |
| Marblehead, .     | 11                       | 56             | 6                 | -        | -          | Randolph, .    | -                        | 1              | -                 | -        | -          |
| MARLBOROUGH, .    | 6                        | 2              | 3                 | 142      | -          | Raynham, .     | -                        | -              | 2                 | -        | -          |
| Maynard, .        | 2                        | 6              | -                 | -        | -          | Reading, .     | 1                        | 3              | 1                 | -        | -          |
| MEDFORD, .        | 5                        | 6              | 6                 | 1        | -          | Rochester, .   | -                        | 1              | 1                 | -        | -          |
| Melrose, .        | -                        | 23             | 3                 | 20       | -          | Rockland, .    | 1                        | 5              | -                 | -        | -          |
| Medway, .         | -                        | 1              | -                 | -        | -          | Rockport, .    | 1                        | 2              | -                 | -        | -          |
| Methuen, .        | 1                        | -              | 1                 | -        | 1          | Rowley, .      | -                        | -              | 6                 | -        | -          |
| Middlefield, .    | -                        | 1              | -                 | -        | -          | SALEM, .       | 7                        | 45             | 37                | -        | -          |
| Middleton, .      | -                        | -              | 1                 | -        | -          | Salisbury, .   | -                        | 2              | -                 | -        | -          |
| Millford, .       | -                        | 1              | 9                 | 1        | -          | Sandisfield, . | -                        | -              | 2                 | -        | -          |
| Millbury, .       | 6                        | 5              | 8                 | 96       | -          | Saugus, .      | -                        | 1              | 2                 | 8        | -          |
| Monson, .         | -                        | 8              | 3                 | 5        | -          | Scituate, .    | 1                        | -              | -                 | -        | -          |
| Montague, .       | -                        | 7              | -                 | -        | -          | Seekonk, .     | -                        | 2              | -                 | -        | -          |
| Natick, .         | 2                        | 17             | 3                 | 8        | -          | Sharon, .      | -                        | 2              | 2                 | -        | -          |
| NEW BEDFORD, .    | 7                        | 76             | 169               | 118      | 2          | Shutesbury, .  | -                        | -              | 1                 | -        | -          |
| NEWBURYPORT, .    | 26                       | 1              | 5                 | -        | -          | Somerset, .    | -                        | -              | -                 | 24       | -          |
| NEWTON, .         | 34                       | 43             | 15                | 3        | -          | SOMERVILLE, .  | 28                       | 193            | 34                | 2        | 1          |
| North Adams, .    | 3                        | 27             | 11                | 2        | 1          | SPRINGFIELD, . | 4                        | 32             | 27                | 12       | 2          |
| NORTHAMPTON, .    | 6                        | 24             | 47                | 22       | -          | Stoneham, .    | 5                        | 4              | -                 | -        | -          |
| North Andover, .  | 1                        | -              | -                 | 3        | -          | Stow, .        | -                        | -              | -                 | 7        | -          |
| No. Attleboro', . | 4                        | 4              | 3                 | -        | -          | Sturbridge, .  | -                        | 1              | -                 | -        | -          |
| No. Brookfield, . | -                        | 6              | -                 | -        | -          | Swampscott, .  | 2                        | 7              | -                 | -        | -          |
| Northfield, .     | -                        | -              | 1                 | -        | -          | TAUNTON, .     | 2                        | 22             | 4                 | -        | -          |

*Cases of Infectious Diseases, etc. — Concluded.*

|                     | Diphtheria<br>and Croup. | Scarlet-fever. | Typhoid<br>Fever. | Measles. | Small-pox. |                                     | Diphtheria<br>and Croup. | Scarlet-fever. | Typhoid<br>Fever. | Measles. | Small-pox. |
|---------------------|--------------------------|----------------|-------------------|----------|------------|-------------------------------------|--------------------------|----------------|-------------------|----------|------------|
| Tewksbury, . . .    | -                        | 1              | -                 | -        | -          | Westford, . . .                     | 1                        | 7              | 1                 | -        | -          |
| Topsfield, . . .    | -                        | -              | 1                 | -        | -          | Westhampton, . .                    | 2                        | -              | -                 | -        | -          |
| Townsend, . . .     | -                        | -              | 1                 | -        | -          | Westminster, . .                    | -                        | 1              | 2                 | -        | -          |
| Upton, . . .        | 1                        | -              | -                 | 2        | -          | West Newbury, . .                   | 5                        | -              | -                 | -        | -          |
| Uxbridge, . . .     | -                        | -              | 2                 | 3        | -          | W. Stockbridge, . .                 | -                        | 4              | -                 | -        | -          |
| Wakefield, . . .    | 12                       | 2              | 1                 | 5        | -          | Weston, . . .                       | -                        | 2              | -                 | -        | -          |
| Wales, . . .        | -                        | 2              | -                 | -        | -          | West Springfield, . .               | -                        | 3              | 1                 | -        | -          |
| WALTHAM, . . .      | 13                       | 5              | 7                 | -        | -          | Weymouth, . . .                     | 2                        | -              | -                 | -        | -          |
| Ware, . . .         | 5                        | 2              | -                 | -        | -          | Whitman, . . .                      | 5                        | 1              | -                 | -        | -          |
| Wareham, . . .      | 2                        | -              | 1                 | -        | -          | Williamstown, . .                   | 1                        | -              | 7                 | -        | -          |
| Warren, . . .       | 1                        | 4              | 2                 | -        | -          | Winchendon, . . .                   | 6                        | -              | 2                 | -        | -          |
| Warwick, . . .      | -                        | -              | -                 | 3        | -          | Winthrop, . . .                     | -                        | 1              | -                 | -        | -          |
| Watertown, . . .    | 2                        | 3              | 3                 | 27       | -          | Winchester, . . .                   | 3                        | 15             | 6                 | -        | -          |
| Wayland, . . .      | 1                        | -              | -                 | -        | -          | Windsor, . . .                      | -                        | -              | -                 | 1        | -          |
| Wenham, . . .       | -                        | 2              | -                 | -        | -          | WOBURN, . . .                       | 18                       | 14             | 6                 | -        | -          |
| Webster, . . .      | 1                        | 1              | 8                 | -        | -          | WORCESTER, . . .                    | 55                       | 55             | 95                | 500      | -          |
| West Boylston, . .  | 3                        | -              | -                 | -        | -          | Other cases of<br>small-pox,* . . . | -                        | -              | -                 | -        | 8          |
| W. Bridgewater, . . | -                        | 9              | -                 | -        | -          | Totals, . . .                       | 1,109                    | 2,914          | 1,525             | 1,503    | 43         |
| Westborough, . . .  | -                        | 2              | -                 | -        | -          |                                     |                          |                |                   |          |            |

Total (including small-pox), . . . . . 7,094

\* These were cases of small-pox reported under the statute of 1883 by cities and towns which made no reports of other diseases under the law of 1893.

The foregoing table shows that exactly one-half of the local boards of health in the State have complied with the law, and have sent returns to the State Board of Health of the cases of disease "dangerous to the public health" reported to them, leaving one-half of the towns from which no reports whatever have been received.

These 175 cities and towns reporting, however, constitute much more than one-half the population, since in this list are embraced all of the cities except Holyoke.



The following classified list contains the names of those towns whose boards of health failed to comply with the terms of the statute of 1893, no reports having been forwarded by them to the State Board of Health of the occurrence of cases of infectious or dangerous diseases. The list of towns is classified according to population.

*I. Cities.*

Holyoke.

*II. Towns having Populations of More than 5,000 in Each.*

|             |                |                    |
|-------------|----------------|--------------------|
| Adams,      | Framingham,    | Revere,            |
| Andover,    | Hyde Park,     | Spencer,           |
| Blackstone, | Middleborough, | Southbridge. — 10. |
| Clinton,    |                |                    |

*III. Towns having a Population of Over 1,000 but Less than 5,000 in Each.*

|                   |                  |                  |
|-------------------|------------------|------------------|
| Abington,         | Hadley,          | Petersham,       |
| Acton,            | Hanover,         | Provincetown,    |
| Ashfield,         | Harvard,         | Rehoboth,        |
| Avon,             | Harwich,         | Royalston,       |
| Barnstable,       | Holbrook,        | Sandwich,        |
| Barre,            | Holden,          | Sheffield,       |
| Belchertown,      | Holliston,       | Shelburne,       |
| Bellingham,       | Hopedale,        | Sherborn,        |
| Billerica,        | Hopkinton,       | Shirley,         |
| Braintree,        | Hubbardston,     | Shrewsbury,      |
| Buckland,         | Hudson,          | Southampton,     |
| Canton,           | Lanesborough,    | South Hadley,    |
| Charlton,         | Lee,             | Southborough,    |
| Chatham,          | Lenox,           | Sterling,        |
| Chester,          | Longmeadow,      | Stockbridge,     |
| Cohasset,         | Manchester,      | Stoughton,       |
| Colrain,          | Marshfield,      | Sudbury,         |
| Dartmouth,        | Mattapoietts,    | Sutton,          |
| Deerfield,        | Medfield,        | Swansea,         |
| Dennis,           | Merrimac,        | Templeton,       |
| Dudley,           | Milton,          | Tisbury,         |
| Duxbury,          | Nantucket,       | Walpole,         |
| East Bridgewater, | Needham,         | Wellesley,       |
| Easton,           | Newbury,         | Wellfleet,       |
| Fairhaven,        | New Marlborough, | West Brookfield, |
| Falmouth,         | Northborough,    | Westport,        |
| Freetown,         | Northbridge,     | Wilbraham,       |
| Georgetown,       | Norton,          | Williamsburg,    |
| Granville,        | Norwell,         | Wilmington,      |
| Great Barrington, | Orleans,         | Wrentham. — 91.  |
| Groveland,        |                  |                  |

*IV. Towns having Less than 1,000 Inhabitants in Each.*

|              |                   |                    |
|--------------|-------------------|--------------------|
| Alford,      | Goshen,           | North Reading,     |
| Ashby,       | Gosnold,          | Otis,              |
| Becket,      | Hamilton,         | Pelham,            |
| Berkley,     | Hancock,          | Peru,              |
| Berlin,      | Hawley,           | Phillipston,       |
| Bernardston, | Heath,            | Plainfield,        |
| Blandford,   | Holland,          | Plympton,          |
| Boxborough,  | Lakeville,        | Prescott,          |
| Boxford,     | Leverett,         | Princeton,         |
| Boylston,    | Leyden,           | Richmond,          |
| Burlington,  | Lynnfield,        | Rowe,              |
| Carver,      | Marion,           | Russell,           |
| Charlemont,  | Mashpee,          | Rutland,           |
| Chilmark,    | Mendon,           | Savoy,             |
| Clarksburg,  | Millis,           | Southwick,         |
| Cummington,  | Monterey,         | Sunderland,        |
| Dana,        | Montgomery.       | Tolland,           |
| Dunstable,   | Monroe,           | Truro,             |
| Eastham,     | Mount Washington, | Tyngsborough,      |
| Enfield,     | Nahant,           | Tyringham,         |
| Florida,     | New Ashford,      | Washington,        |
| Gay Head,    | New Braintree,    | Wendell,           |
| Gill,        | New Salem,        | Whateley,          |
| Granby,      | Norfolk,          | Worthington. — 73. |
| Greenwich,   |                   |                    |

A review of this classified list leads to some conclusions as to the causes of the failure of so large a number to comply with the provisions of the statutes.

In the first place, the ratio of the population of the cities and towns failing to report in each of the foregoing classes as compared with the total population of the towns of each class shows that the cities and large towns have complied with the provisions of the act much more generally than the small towns.

In Class I., the cities, Holyoke is the only city failing to comply, and its population, by census of 1890, constitutes but 2.5 per cent. of the population represented in Class I.

In Class II. the population of the ten towns failing to report was 25.7 per cent. of the total population of the towns of that class.

In Class III. the population of the ninety-one towns failing to report was 48 per cent. of the total population of the towns of that class.

In Class IV. the population of the seventy-three towns failing to report was 75 per cent. of the total population of the towns of that class.

This great difference between the action of the authorities of cities and of small towns in this matter suggests two definite reasons for the considerable degree of non-compliance with the terms of the statute.

1. The non-existence of separate local boards of health in small towns having an organization for sanitary purposes only. An inquiry of the State Board made a few years since showed that boards of health independent of the selectmen existed in only one-half of the towns in the State. This being the case, the selectmen acting as boards of health are largely interested in matters of an economic or administrative character not closely related to the public health, and as a consequence matters pertaining to the health of towns are much neglected, and among them, undoubtedly, the reporting of cases of infectious diseases.

Many attempts to remedy this defect by legislative action have been made in past years, but with little success.

2. As a matter of fact infectious diseases do not prevail in sparsely settled populations to so great an extent as among the densely settled suburban districts, so that there were undoubtedly some of the very small towns in which none of the specified diseases occurred during the year. This fact is brought out very clearly in the twenty-third report of the Board (1891), wherein is shown the relation of the mortality from eight different diseases, most of them of the infectious class, to the density of the population.

While the mortality does not necessarily represent the prevalence of disease it bears a very close relation to it. In that report it was shown that for a period of twenty years (1871-90) there were two towns in the State in which there had been no deaths from diphtheria and croup, fifteen towns in which there had been no deaths from scarlet-fever, one town in which there had been no deaths from typhoid fever, 183 towns in which there had been no deaths from small-pox and ninety-five towns in which there had been no deaths from measles.

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# FOOD AND DRUG INSPECTION.

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## FOOD AND DRUG INSPECTION.

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The following report comprises the work of the Board for the year ending Sept. 30, 1893, in the inspection of food and drugs.

The force employed in this department of work was the same as that of the previous year, and consisted of the following :—

|                             |           |                           |
|-----------------------------|-----------|---------------------------|
| Dr. CHARLES P. WORCESTER,   | . . . . . | <i>Analyst.</i>           |
| Prof. CHARLES A. GOESSMANN, | . . . . . | <i>Analyst.</i>           |
| Mr. ALBERT E. LEACH,        | . . . . . | <i>Assistant Analyst.</i> |
| JOHN H. TERRY,              | . . . . . | <i>Inspector.</i>         |
| JOHN F. McCAFFREY,          | . . . . . | <i>Inspector.</i>         |
| HORACE F. DAVIS,            | . . . . . | <i>Inspector.</i>         |

The work of the Board in this department has been conducted during the year in the laboratory at 994 Washington Street, Boston, temporarily occupied for this purpose until the new laboratory in the State House Extension is completed.

The whole number of samples of food and drugs examined during the year was 6,409, making the whole number examined 53,573 for the entire period since the enactment of the general food and drug acts in 1882. This number (6,409) was greater than that of any previous year.

The following summary embraces the work done during the year :—

|                                                            |           |       |
|------------------------------------------------------------|-----------|-------|
| Number of samples of milk examined,                        | . . . . . | 8,078 |
| Number of samples above standard,                          | . . . . . | 1,545 |
| Number of samples below standard,                          | . . . . . | 1,528 |
| Percentage of adulteration or deficiency,                  | . . . . . | 49.7  |
| Number of samples of other kinds of food (not milk),       | . . . . . | 8,009 |
| Number of samples above standard,                          | . . . . . | 2,637 |
| Number of samples below standard,                          | . . . . . | 372   |
| Percentage of adulteration,                                | . . . . . | 12.8  |
| Number of samples of drugs examined,                       | . . . . . | 827   |
| Number of samples of good quality,                         | . . . . . | 228   |
| Number of samples adulterated, as defined by the statutes, | . . . . . | 99    |
| Percentage of adulteration,                                | . . . . . | 30.8  |
| Total examinations of food and drugs,                      | . . . . . | 6,409 |
| Total examinations of good quality,                        | . . . . . | 4,410 |
| Total examinations not conforming to the statutes,         | . . . . . | 1,999 |
| Percentage of adulteration,                                | . . . . . | 31.2  |

## STATISTICAL SUMMARY.

FOOD AND DRUG INSPECTION (1883-1893).

| SUMMARY.                                                                  | YEARS.     |            |            |            |            |            |  |
|---------------------------------------------------------------------------|------------|------------|------------|------------|------------|------------|--|
|                                                                           | 1883.      | 1884.      | 1885.      | 1886.      | 1887.      | 1888.      |  |
| Number of samples of milk examined, . . . . .                             | 218        | 1,123      | 2,219      | 2,086      | 3,081      | 2,825      |  |
| Number of samples above standard, . . . . .                               | 35         | 347        | 1,297      | 1,323      | 1,900      | 1,706      |  |
| Number of samples below standard, . . . . .                               | 183        | 776        | 922        | 762        | 1,181      | 1,120      |  |
| Percentage of adulteration, . . . . .                                     | 83.9       | 69.1       | 41.7       | 36.5       | 38.3       | 39.6       |  |
| Number of samples of other kinds of food (not milk), . . . . .            | 477        | 839        | 1,552      | 1,353      | 1,789      | 2,079      |  |
| Number of samples of good quality, . . . . .                              | 328        | 432        | 863        | 863        | 1,203      | 1,690      |  |
| Number of samples adulterated, as defined by the statutes, . . . . .      | 149        | 407        | 689        | 490        | 586        | 389        |  |
| Percentage of adulteration, . . . . .                                     | 31.2       | 48.5       | 43.1       | 36.2       | 29.4       | 19.2       |  |
| Number of samples of drugs examined, . . . . .                            | 603        | 682        | 1,007      | 898        | 550        | 802        |  |
| Number of samples of good quality, . . . . .                              | 357        | 431        | 571        | 463        | 400        | 634        |  |
| Number of samples adulterated, as defined by the statutes, . . . . .      | 246        | 251        | 436        | 435        | 150        | 228        |  |
| Percentage of adulteration, . . . . .                                     | 40.8       | 36.8       | 43.3       | 47.8       | 27.3       | 28.4       |  |
| Total examinations of food and drugs, . . . . .                           | 1,298      | 2,644      | 4,778      | 4,326      | 5,450      | 6,766      |  |
| Total examinations of good quality, . . . . .                             | 720        | 1,310      | 2,751      | 2,649      | 3,603      | 4,019      |  |
| Total examinations not conforming to the statutes, . . . . .              | 578        | 1,434      | 2,027      | 1,677      | 1,847      | 1,747      |  |
| Percentage of adulteration, . . . . .                                     | 44.5       | 54.2       | 42.7       | 38.7       | 34.3       | 25.3       |  |
| Expense of collection, examination and prosecution, . . . . .             | \$2,931 56 | \$5,529 60 | \$8,557 43 | \$8,025 34 | \$8,803 62 | \$8,915 41 |  |
| Expense of collection, examination and prosecution, per sample, . . . . . | 2 26       | 2 09       | 1 79       | 1 85       | 1 62       | 1 54       |  |

FOOD AND DRUG INSPECTION (1883-1893) — *Concluded.*

| SUMMARY.                                                                  | YEARS.      |             |             |             |             | TOTALS.     |
|---------------------------------------------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|
|                                                                           | 1889.       | 1890.       | 1891.       | 1892.       | 1893.       |             |
| Number of samples of milk examined, . . . . .                             | 3,219       | 3,256       | 2,726       | 3,271       | 3,073       | 27,076      |
| Number of samples above standard, . . . . .                               | 1,971       | 1,858       | 1,629       | 1,757       | 1,545       | 16,367      |
| Number of samples below standard, . . . . .                               | 1,248       | 1,378       | 1,097       | 1,514       | 1,528       | 11,709      |
| Percentage of adulteration, . . . . .                                     | 38.7        | 42.6        | 40.2        | 46.3        | 49.7        | 43.2        |
| Number of samples of other kinds of food examined (not milk), . . . . .   | 1,635       | 2,349       | 2,144       | 2,441       | 3,009       | 19,067      |
| Number of samples of good quality, . . . . .                              | 1,242       | 1,913       | 1,577       | 2,042       | 2,637       | 14,800      |
| Number of samples adulterated, as defined by the statutes, . . . . .      | 393         | 436         | 567         | 399         | 372         | 4,807       |
| Percentage of adulteration, . . . . .                                     | 24.0        | 18.6        | 26.4        | 16.3        | 12.3        | 24.4        |
| Number of samples of drugs examined, . . . . .                            | 600         | 400         | 424         | 487         | 327         | 6,830       |
| Number of samples of good quality, . . . . .                              | 503         | 325         | 352         | 312         | 228         | 4,576       |
| Number of samples adulterated, as defined by the statutes, . . . . .      | 97          | 75          | 72          | 175         | 99          | 2,254       |
| Percentage of adulteration, . . . . .                                     | 16.2        | 18.7        | 17.0        | 35.9        | 30.3        | 22.0        |
| Total examinations of food and drugs, . . . . .                           | 5,454       | 5,985       | 5,294       | 6,190       | 6,409       | 53,573      |
| Total examinations of good quality, . . . . .                             | 3,716       | 4,096       | 3,558       | 4,111       | 4,410       | 34,803      |
| Total examinations not conforming to the statutes, . . . . .              | 1,738       | 1,889       | 1,736       | 2,088       | 1,999       | 18,770      |
| Percentage of adulteration, . . . . .                                     | 31.9        | 31.5        | 32.8        | 33.7        | 31.2        | 35.0        |
| Expense of collection, examination and prosecution, . . . . .             | \$10,356 28 | \$10,013 04 | \$10,019 41 | \$11,180 30 | \$10,454 11 | \$94,780 10 |
| Expense of collection, examination and prosecution, per sample, . . . . . | 1 89        | 1 67        | 1 89        | 1 80        | 1 63        | 1 77        |



It would be manifestly impossible from the statistics presented in the foregoing table to form a definite conclusion either in relation to the extent of adulteration of food which exists in Massachusetts or of its relative prevalence when the same statistics are compared with those of other countries conducting a similar line of work.

The reasons for the very marked contrast between the results reported by the British analysts and those of Massachusetts are stated in the last Report of the Board (24th report, p. 608), and one of these reasons appears to be shown more clearly in the present report wherein the general table of statistics has been rearranged in such a manner as to present the ratio of adulteration of "other samples of food," not including milk.

To what extent the legal standard of milk in Massachusetts affects the ratio of adulteration, as published in the foregoing table, may be shown by the following statement.

Out of 2,235 samples of milk taken by the inspectors of the Board in the years 1886-1889, the total solids of which were known, and all of which contained less than 13 per cent. of solids, 1,504 or 67.3 per cent. contained from 12 to 13 per cent. of solids. Nearly all of these and many more would, under the standards of most countries which have adopted a standard, have been deemed to be milk of good standard quality, since the standard in most countries is 11.50 of total solids. But in Massachusetts all of this number, except those which were collected in the months of May and June, must be reckoned as adulterated milk. The effect of this statutory provision upon the published ratio of adulteration consequently gives to our published statistics an unfavorable showing, which at the first glance might be easily misconstrued. The statistics presented in Dr. Worcester's report for the present year still further confirm this statement.

As a matter of fact, however, actual or intentional adulteration of this most important article of food is much less common than it was found to be at the beginning of the period of active enforcement of the laws relating to food and drug inspection.

The continuous work of the Board and the marked improvement in local inspection in cities have effected a marked change, which nothing but vigilant and continuous supervision could have accomplished.

*What is Adulterated Milk?*

The high percentages of samples of milk which are shown by the continuous reports of the Board to be below the legal standard of 13 per cent. of solids make it necessary to make an occasional statement of the cause.

The term "adulterated milk," under the statutes of Massachusetts, may signify milk which is simply below the legal standard of 13 per cent. of solids and nothing more, or, in other words, a natural milk, just as produced by the cow, having no other disqualification except its deficiency in total solids. The "percentage of adulteration" reported by the Board in its monthly bulletins is largely made up of this class of samples.

The second form of "adulterated milk" consists of milk which has been subjected to certain alterations by human interference. These are chiefly the addition of water, the removal of cream, the addition of coloring matter and of substances employed to preserve the milk from souring.

This second class is very much smaller in number than the former class. It is not practicable to separate the two classes and to draw an exact line between them, but it is certain that the ratio of the class of samples intentionally adulterated is very much less than it was before active measures were taken for the suppression of such conditions.

In 1884 the Board made a large number of examinations of natural milk, the samples in all cases being collected by inspectors who witnessed the milking. From the results of these analyses it would be safe to say that out of 100 samples taken at random from 100 animals throughout the different dairies in the State under varying conditions of breed, of age, time of year and methods of feeding, about thirty would prove to be below the legal standard of 13 per cent. of solids.

Among this 30 per cent. of animals the ratio of Holstein cows would probably be greater than the ratio of such cows among the 70 per cent. whose milk is found to be above the legal standard.

Very careful attention has been given to this subject in other countries, where the subject of milk inspection is deemed of very high importance, both in its sanitary and in its economic relations.

In a recent article in the *Zeitschrift für Fleisch und Milch Hygiene*, Dr. Martiny states that the percentage of the various constituents of milk to be used as a standard must be determined by the average percentage found in a given district, since this may vary somewhat. Milk in North Germany is not quite so rich in solids as that of South Germany, and in the former it shows an average of 3.3 per cent. of fat in 12 per cent. of dried solids, with a specific gravity of 1031.5, while in the latter the average solids are 12.4 per cent. and the fat 3.5.

The same writer states his belief that the percentage of fats may be increased to more than 4 per cent. in a total of 13 or 14 per cent. of solids by appropriate feeding.

The methods of feeding employed in many of the dairies which furnish the milk supply of our large cities are those which are intended to secure an increased quantity of milk at the expense of its quality, and the selection of breeds of cows whose milk is notoriously poor in quality acts in the same direction of impoverishing the quality of the milk.

In commenting upon the difficulty of subjecting to inspection the entire milk supply of a city at frequent intervals, Martiny concludes that—

1. The sale of milk should only be allowed by officially designated dealers, and in order to facilitate frequent inspection he suggests the limitation of the number of vendors of milk as is done in England and in Italy.

2. Dealers should give evidence of an intelligent knowledge of the requirements necessary for the sale of pure milk both from a sanitary and from an economic point of view.

3. Milk inspection should not be confined to market milk but should extend to the dairies.

4. In every city a well-equipped laboratory should be maintained for the scientific examination of milk.

It is gratifying to know that since the enactment of the general statute of 1882 (chap. 263), and the work which has followed during the ten years or more which have elapsed, very much more attention has been given to milk inspection by local authorities. Several of the principal cities of the State employ the services of trained inspectors who devote either the whole or a considerable portion of their time to the careful analysis of milk by laboratory

methods, and the number of such cities which find it to be for their interest to employ a trained inspector is gradually increasing.

The report of the analyst also shows that the artificial coloring of milk, once quite a common practice in the large cities, is now very rarely found, the vigorous warfare against this objectionable form of adulteration having practically suppressed it.

Among the examinations of milk reported by the analyst special attention is called to the report upon condensed milk, an article which is now largely used and has a wide field of usefulness as a convenient form of food for special purposes.

#### FOOD, OTHER THAN MILK.

In the examination of other kinds of food during the year special attention has been given to the examination of the most important and widely used of all foods — bread; and also of cheese, another valuable article of nutriment.

The points of interest noted in regard to bread are the weight of loaves, the percentage of water and of solids, the per cent. of ash in terms of solids, the acidity and the price charged for each loaf.

The average weight of loaves was found to be 404 grammes, or  $13\frac{1}{2}$  ounces.

The per cent. of moisture was quite uniform, in most instances being about 42 or 43 per cent. of the weight of the loaf, leaving 57 or 58 per cent. of solids.

The price was quite uniformly five cents per loaf, rarely four cents, for loaves of ordinary size and weight.

No adulterations are mentioned by the analyst, and at the low price of flour in the United States the adulteration of flour or of bread is of extremely rare occurrence.

The examination of samples of cheese showed a fairly uniform quality and price, the latter being at sixteen cents per pound.

Omitting four samples of special sorts, the average total solids were found to be 66.3 per cent., the fat 35 per cent., the solids, not fat, 31.3 per cent., and the water 33.6 per cent.

The following tables present the usual statistics relative to the notices sent by the Board to parties (usually retailers) from whom samples of adulterated food or drugs have been obtained during the year : —

*Cities and Towns to which Notices were sent on Account of Adulterated Articles of Food other than Milk.*

|                         |    |                             |     |
|-------------------------|----|-----------------------------|-----|
| Adams, . . . . .        | 4  | New Bedford, . . . . .      | 1   |
| Boston, . . . . .       | 43 | North Adams, . . . . .      | 5   |
| Cambridge, . . . . .    | 17 | North Brookfield, . . . . . | 1   |
| Everett, . . . . .      | 1  | Orange, . . . . .           | 1   |
| Fall River, . . . . .   | 17 | Pittsfield, . . . . .       | 5   |
| Gilbertville, . . . . . | 2  | Taunton, . . . . .          | 1   |
| Gloucester, . . . . .   | 6  | Ware, . . . . .             | 1   |
| Holyoke, . . . . .      | 4  | Webster, . . . . .          | 1   |
| Hopedale, . . . . .     | 1  |                             |     |
| Lowell, . . . . .       | 1  | Total, . . . . .            | 113 |
| Medford, . . . . .      | 1  |                             |     |

*Cities and Towns to which Notices were sent on Account of Adulterated Milk.*

|                            |    |                             |     |
|----------------------------|----|-----------------------------|-----|
| Boston, . . . . .          | 10 | Newton, . . . . .           | 6   |
| Brockton, . . . . .        | 1  | Norwood, . . . . .          | 2   |
| Brookline, . . . . .       | 1  | Orange, . . . . .           | 1   |
| Cambridge, . . . . .       | 97 | Pittsfield, . . . . .       | 1   |
| Canton, . . . . .          | 1  | Plymouth, . . . . .         | 2   |
| Chelsea, . . . . .         | 10 | Provincetown, . . . . .     | 3   |
| Dedham, . . . . .          | 7  | Quincy, . . . . .           | 3   |
| Everett, . . . . .         | 10 | Revere, . . . . .           | 7   |
| Fall River, . . . . .      | 6  | Salem, . . . . .            | 12  |
| Fitchburg, . . . . .       | 4  | Salisbury Beach, . . . . .  | 1   |
| Gloucester, . . . . .      | 15 | Somerville, . . . . .       | 31  |
| Grafton, . . . . .         | 1  | South Framingham, . . . . . | 1   |
| Hyde Park, . . . . .       | 6  | Springfield, . . . . .      | 3   |
| Lawrence, . . . . .        | 3  | Stoneham, . . . . .         | 1   |
| Littleton, . . . . .       | 2  | Taunton, . . . . .          | 1   |
| Lynn, . . . . .            | 22 | Walpole, . . . . .          | 1   |
| Malden, . . . . .          | 21 | Waltham, . . . . .          | 2   |
| Marblehead, . . . . .      | 2  | Watertown, . . . . .        | 3   |
| Medfield, . . . . .        | 3  | Woburn, . . . . .           | 15  |
| Medford, . . . . .         | 5  | Worcester, . . . . .        | 5   |
| Milford, . . . . .         | 2  |                             |     |
| Nantasket Beach, . . . . . | 2  | Total, . . . . .            | 274 |
| New Bedford, . . . . .     | 2  |                             |     |

*Cities and Towns to which Notices were sent on Account of Adulterated Drugs.*

|                        |    |                         |    |
|------------------------|----|-------------------------|----|
| Adams, . . . . .       | 1  | North Adams, . . . . .  | 1  |
| Amherst, . . . . .     | 2  | Palmer, . . . . .       | 1  |
| Boston, . . . . .      | 17 | Provincetown, . . . . . | 1  |
| Brookline, . . . . .   | 1  | Springfield, . . . . .  | 1  |
| Gloucester, . . . . .  | 3  | Taunton, . . . . .      | 5  |
| Millis, . . . . .      | 1  |                         |    |
| New Bedford, . . . . . | 2  | Total, . . . . .        | 36 |

## PROSECUTIONS.

In the last report a condensed summary of the prosecutions conducted by the Board for the entire period since the enactment of the food and drug statutes was presented. The same table is herewith published, together with the results of the prosecutions of the year ending Sept. 30, 1893:—

*Number of Complaints Entered in Court.*

| YEAR.             | Food<br>not including<br>Milk. | Drugs. | Milk. | Total. | Convictions. | Fines Imposed. |
|-------------------|--------------------------------|--------|-------|--------|--------------|----------------|
| 1883, . . . . .   | —                              | 5      | 4     | 9      | 8            | —†             |
| 1884, . . . . .   | 2                              | 1      | 45    | 48     | 44           | —†             |
| 1885,* . . . . .  | 50                             | 1      | 68    | 119    | 103          | —†             |
| 1886,† . . . . .  | 10                             | —      | 10    | 20     | 19           | —†             |
| 1887, . . . . .   | 30                             | —      | 34    | 64     | 60           | —†             |
| 1888, . . . . .   | 22                             | —      | 43    | 65     | 61           | \$2,042 00     |
| 1889, . . . . .   | 74                             | —      | 66    | 140    | 124          | 3,889 00       |
| 1890, . . . . .   | 78                             | —      | 24    | 102    | 96           | 3,919 00       |
| 1891, . . . . .   | 96                             | 5      | 49    | 150    | 135          | 2,668 00       |
| 1892, . . . . .   | 52                             | 12     | 72    | 136    | 123          | 3,661 70       |
| 1893, . . . . .   | 26                             | 3      | 67    | 96     | 92           | 2,476 00       |
| Totals, . . . . . | 440                            | 27     | 482   | 949    | 865          | 18,655 70      |

\* To May 1, 1886.

† Four months only.

‡ No record kept.

Ratio of convictions to complaints, 91.1 per cent.

NOTE. — All complaints entered before May 1, 1886, were under the direction of the Board of Health, Lunacy and Charity, and all after that date were under the direction of the State Board of Health.

Under the provisions of chapter 289 of the Acts of 1884, which require the Board to report annually to the Legislature the "number of prosecutions made under" the food and drug acts, "and an itemized account of all money expended in carrying out the provisions thereof," the following report was transmitted to the General Court in January, 1894:—

OFFICE OF THE STATE BOARD OF HEALTH,  
13 BEACON STREET, BOSTON, JANUARY, 1894.

*To the Honorable Senate and House of Representatives of the Commonwealth of Massachusetts, in General Court assembled.*

The following summary is made in compliance with the provisions of chapter 289, section 2, of the Acts of 1884, requiring the State Board of Health to "report annually to the Legislature the number of prosecutions made under chapter 263 of the Acts of 1882, and an itemized account of all money expended in carrying out the provisions thereof."

The whole number of prosecutions made by authority of the Board against offenders, under the provisions of the food and drug acts, for the year ending Sept. 30, 1893, was 96.

The cities and towns in which the articles were sold, and in respect to which complaints were entered in court, the character of the articles found to be adulterated, or fraudulently sold, the dates of the trials and their result, are presented in the following table:—

### MILK AND MILK PRODUCTS.

#### *Complaints Entered for Fraudulent Sales of Milk.*

| PLACE.              | DATE.                 | RESULT.    |
|---------------------|-----------------------|------------|
| In Boston, . . . .  | Aug. 1, 1893, . . .   | Convicted. |
| Cambridge, . . . .  | June 9, 1893, . . .   | "          |
| Cambridge, . . . .  | June 17, 1893, . . .  | "          |
| Chelsea, . . . .    | March 24, 1893, . . . | "          |
| Fall River, . . . . | April 27, 1893, . . . | "          |
| Fall River, . . . . | May 4, 1893, . . .    | "          |
| Fall River, . . . . | May 4, 1893, . . .    | "          |
| Fall River, . . . . | May 4, 1893, . . .    | "          |
| Fall River, . . . . | May 4, 1893, . . .    | "          |
| Fall River, . . . . | June 20, 1893, . . .  | "          |
| Salem, . . . .      | April 29, 1893, . . . | "          |
| Salem, . . . .      | April 29, 1893, . . . | "          |
| Salem, . . . .      | April 29, 1893, . . . | "          |

*For Fraudulent Sales of Milk*—Continued.

| PLACE.               | DATE.           | RESULT.                  |
|----------------------|-----------------|--------------------------|
| In Salem, . . . .    | April 29, 1893, | Convicted.               |
| Salem, . . . .       | June 26, 1893,  | "                        |
| Salem, . . . .       | Aug. 28, 1893,  | "                        |
| Salem, . . . .       | Aug. 28, 1893,  | "                        |
| Salem, . . . .       | Aug. 28, 1893,  | "                        |
| Taunton, . . . .     | July 29, 1893,  | "                        |
| Taunton, . . . .     | July 29, 1893,  | "                        |
| Gloucester, . . . .  | Jan. 3, 1893,   | "                        |
| Gloucester, . . . .  | Aug. 2, 1893,   | "                        |
| Gloucester, . . . .  | Aug. 31, 1893,  | "                        |
| Quincy, . . . .      | Aug. 24, 1893,  | "                        |
| Quincy, . . . .      | Aug. 24, 1893,  | "                        |
| Chicopee, . . . .    | June 9, 1893,   | "                        |
| Woburn, . . . .      | Nov. 16, 1892,  | "                        |
| Spencer, . . . .     | Oct. 18, 1892,  | "                        |
| Hardwick, . . . .    | Oct. 5, 1892,   | "                        |
| Lee, . . . .         | Oct. 25, 1892,  | "                        |
| Carlisle, . . . .    | Nov. 25, 1892,  | "                        |
| North Adams, . . . . | Nov. 10, 1892,  | "                        |
| Greenfield, . . . .  | Nov. 11, 1892,  | "                        |
| Oakham, . . . .      | Jan. 28, 1893,  | "                        |
| Canton, . . . .      | Jan. 11, 1893,  | "                        |
| Dedham, . . . .      | Feb. 23, 1893,  | "                        |
| Sutton, . . . .      | March 24, 1893, | "                        |
| Berlin, . . . .      | May 20, 1893,   | "                        |
| Topsfield, . . . .   | May 20, 1893,   | "                        |
| Walpole, . . . .     | June 13, 1893,  | "                        |
| Walpole, . . . .     | June 13, 1893,  | "                        |
| Walpole, . . . .     | Sept. 7, 1893,  | "                        |
| Dover, . . . .       | June 3, 1893,   | "                        |
| Upton, . . . .       | July 31, 1893,  | "                        |
| Upton, . . . .       | July 31, 1893,  | "                        |
| Westport, . . . .    | July 26, 1893,  | "                        |
| Westport, . . . .    | July 26, 1893,  | Plea of nolo contendere. |
| Millis, . . . .      | Aug. 25, 1893,  | Convicted.               |
| Medfield, . . . .    | Aug. 25, 1893,  | "                        |
| Medfield, . . . .    | Aug. 25, 1893,  | "                        |
| Medfield, . . . .    | Aug. 25, 1893,  | "                        |
| Norwood, . . . .     | Sept. 2, 1893,  | "                        |
| Norwood, . . . .     | Sept. 7, 1893,  | "                        |
| Norwood, . . . .     | Sept. 30, 1893, | "                        |



*For Fraudulent Sales of Milk — Concluded.*

| PLACE.              | DATE.                 | RESULT.    |
|---------------------|-----------------------|------------|
| In Mendon, . . .    | Sept. 2, 1893, . . .  | Convicted. |
| Mendon, . . .       | Sept. 2, 1893, . . .  | "          |
| Upton, . . .        | Sept. 2, 1893, . . .  | "          |
| Upton, . . .        | Sept. 2, 1893, . . .  | "          |
| Wrentham, . . .     | Sept. 25, 1893, . . . | "          |
| Provincetown, . . . | Sept. 1, 1893, . . .  | "          |
| Total, 61 cases.    |                       |            |

*For Fraudulent Sales of Butter.*

|                  |                       |            |
|------------------|-----------------------|------------|
| In Boston, . . . | Dec. 28, 1892, . . .  | Convicted. |
| Boston, . . .    | March 22, 1893, . . . | "          |
| Lowell, . . .    | Jan. 21, 1893, . . .  | "          |
| Lowell, . . .    | Jan. 21, 1893, . . .  | "          |
| Lowell, . . .    | Jan. 21, 1893, . . .  | "          |
| Lowell, . . .    | Jan. 21, 1893, . . .  | "          |
| Total, 6 cases.  |                       |            |

## OTHER ARTICLES OF FOOD.

*Maple Syrup.*

|                   |                       |            |
|-------------------|-----------------------|------------|
| In Boston, . . .  | March 21, 1893, . . . | Acquitted. |
| Fall River, . . . | April 27, 1893, . . . | Convicted. |
| Fall River, . . . | May 4, 1893, . . .    | "          |

*Maple Sugar.*

|                  |                       |            |
|------------------|-----------------------|------------|
| In Boston, . . . | April 19, 1893, . . . | Convicted. |
| Boston, . . .    | April 19, 1893, . . . | "          |

*Honey.*

|                  |                      |            |
|------------------|----------------------|------------|
| In Boston, . . . | Oct. 11, 1892, . . . | Convicted. |
|------------------|----------------------|------------|

*Coffee.*

|                                |                       |            |
|--------------------------------|-----------------------|------------|
| In Boston, . . .               | Nov. 29, 1892, . . .  | Convicted. |
| Boston, . . .                  | Dec. 15, 1892, . . .  | "          |
| Boston, . . .                  | March 21, 1893, . . . | "          |
| North Adams, . . .             | Oct. 20, 1892, . . .  | "          |
| North Adams, . . .             | Dec. 17, 1892, . . .  | "          |
| Hardwick (Gilbertville), . . . | Oct. 31, 1892, . . .  | "          |

*Molasses.*

| PLACE.            | DATE.                 | RESULT.    |
|-------------------|-----------------------|------------|
| In Taunton, . . . | Sept. 23, 1893, . . . | Convicted. |
| Fall River, . . . | June 20, 1893, . . .  | "          |
| Fall River, . . . | June 20, 1893, . . .  | "          |

*Cassia.*

|                      |                       |            |
|----------------------|-----------------------|------------|
| In Fall River, . . . | April 20, 1893, . . . | Convicted. |
|----------------------|-----------------------|------------|

*Cloves.*

|                               |                      |            |
|-------------------------------|----------------------|------------|
| In Hardwick (Gilbertville), . | Oct. 31, 1892, . . . | Convicted. |
| North Adams, . . .            | Dec. 17, 1892, . . . | "          |

*Pepper.*

|                               |                       |            |
|-------------------------------|-----------------------|------------|
| In Hardwick (Gilbertville), . | Oct. 31, 1892, . . .  | Convicted. |
| Fall River, . . .             | April 20, 1893, . . . | Acquitted. |
| Taunton, . . .                | Sept. 23, 1893, . . . | Convicted. |

*Mustard.*

|                       |                       |            |
|-----------------------|-----------------------|------------|
| In North Adams, . . . | Dec. 17, 1892, . . .  | Convicted. |
| Boston, . . .         | March 21, 1893, . . . | "          |
| Gloucester, . . .     | Aug. 2, 1893, . . .   | "          |

*Cream of Tartar.*

|                               |                      |            |
|-------------------------------|----------------------|------------|
| In Hardwick (Gilbertville), . | Oct. 31, 1892, . . . | Convicted. |
| Boston, . . .                 | Nov. 29, 1892, . . . | "          |

Total, 26 cases.

*DRUGS.*

|                      |                      |            |
|----------------------|----------------------|------------|
| In Pittsfield, . . . | Nov. 17, 1892, . . . | Acquitted. |
| North Adams, . . .   | Nov. 10, 1892, . . . | Convicted. |
| Boston, . . .        | April 7, 1893, . . . | "          |

Total, 3 cases.

*SUMMARY.*

|                                                                                                        |           |
|--------------------------------------------------------------------------------------------------------|-----------|
| Complaints entered in court under the acts relating to inspection of milk and milk products, . . . . . | 67 cases. |
| Other articles of food, . . . . .                                                                      | 26 "      |
| Drugs, . . . . .                                                                                       | 3 "       |
| Total, . . . . .                                                                                       | 96 cases. |

## SUMMARY.

The whole number of complaints entered by the State Board of Health in the courts of the Commonwealth against parties for violation of the acts relating to food and drug inspection was 96. In 92, or 95.8 per cent. of these, the parties were convicted. Four were discharged, either in the lower or in the upper courts.

Of the foregoing cases, 61 were for violation of the laws relating to milk adulteration, of which number 60 resulted in conviction.

Nearly all of the cases entered for violation of the statutes relating to the sale of milk were entered under the statute which provides that milk offered for sale shall be of good standard quality, the standard being defined by law.

Six complaints were entered under the oleomargarine laws, each of which resulted in conviction.

There were also twenty-six complaints for fraudulent sales of other articles of food, in all of which except two the parties were convicted. In one of these, a complaint for fraudulent sale of maple syrup, it was claimed that the crate or wholesale package was marked with the word "compound," although the retail package had no such mark to indicate the character of its contents. This is only one of many instances which illustrate the difficulties which are liable to arise under the provision by which certain articles may be sold of an inferior quality, "provided that the same are not injurious to health, and are distinctly labelled as mixtures or compounds."

The articles of food embraced in the foregoing list were the following:—

Maple syrup, 3 cases; maple sugar, 2; honey, 1; coffee, 6; molasses, 3; cassia, 1; cloves, 2; pepper, 3; mustard, 3; cream of tartar, 2.

Of the samples of drugs which were the cause of complaints at court, one case was for refusal to furnish samples to an inspector; another was for a sale of a poisonous cosmetic; and the other was for a sale of McMunn's Elixir, which was not properly marked with a poison label, in compliance with the Statute of 1888 (chapter 209).

The standard of whole milk in Massachusetts is 13 per cent. of *solid* residue, except in the months of May and June, when it is 12

per cent. The following list presents the total solids in the samples of milk upon which complaints in court were founded : —

|      |       |       |       |       |
|------|-------|-------|-------|-------|
| 4.72 | 9.80  | 10.33 | 10.70 | 11.15 |
| 8.25 | 9.82  | 10.40 | 10.73 | 11.16 |
| 8.48 | 9.82  | 10.40 | 10.75 | 11.20 |
| 8.85 | 9.95  | 10.45 | 10.79 | 11.30 |
| 9.15 | 10.02 | 10.50 | 10.80 | 11.35 |
| 9.29 | 10.21 | 10.50 | 10.94 | 11.48 |
| 9.31 | 10.21 | 10.55 | 11.00 | 11.48 |
| 9.35 | 10.25 | 10.56 | 11.04 | 11.52 |
| 9.44 | 10.26 | 10.60 | 11.12 | 11.74 |
| 9.56 | 10.26 | 10.63 | 11.12 | 13.33 |

The total number of samples of food and drugs examined during the year was as follows : —

|                                   |       |
|-----------------------------------|-------|
| Milk, . . . . .                   | 3,224 |
| Other articles of food, . . . . . | 3,009 |
| Drugs, . . . . .                  | 327   |
|                                   | <hr/> |
| Total, . . . . .                  | 6,560 |

|                                                              |             |
|--------------------------------------------------------------|-------------|
| Total expenses of collection, examination and prosecution, . | \$10,454 11 |
| Average expense per sample collected, . . . . .              | 1 59        |

### FINES.

The amount of the fines paid into the treasuries of counties, cities and towns under the provisions of the general and special laws relative to the inspection of food and drugs was as follows : —

*Fines paid for Violation of the Food and Drug Acts, upon Cases entered for the Year ending Sept. 30, 1893.*

|                                                                                |            |
|--------------------------------------------------------------------------------|------------|
| Under the provisions of the laws relating to milk and milk products, . . . . . | \$1,991 00 |
| Under the provisions of laws relative to other articles of food, . . . . .     | 459 00     |
| Under the provisions of laws relative to drugs, . . . . .                      | 26 00      |
|                                                                                | <hr/>      |
| Total, . . . . .                                                               | \$2,476 00 |

## EXPENDITURES

*Under the Provisions of the Food and Drug Acts during the Year ending Sept. 30, 1893.*

|                                                 | FOR THE ENFORCEMENT OF THE STATUTES<br>RELATING TO FOOD AND DRUG<br>INSPECTION. |                                                  |
|-------------------------------------------------|---------------------------------------------------------------------------------|--------------------------------------------------|
|                                                 | Relative to Milk<br>and Milk Products.                                          | Relative to Other<br>Kinds of Food and<br>Drugs. |
| Salaries of analysts, . . . . .                 | \$2,700 00                                                                      | \$1,700 00                                       |
| Salaries of inspectors, . . . . .               | 2,400 00                                                                        | 1,500 00                                         |
| Travelling expenses and purchase of samples, .  | 997 05                                                                          | 664 70                                           |
| Apparatus and chemicals, . . . . .              | 145 00                                                                          | 90 63                                            |
| Rent at Harvard Medical School, . . . . .       | 75 00                                                                           | 50 00                                            |
| Chemical analysis (by other chemists), . . . .  | -                                                                               | 2 00                                             |
| Furniture and fittings at laboratory, . . . . . | 20 00                                                                           | 6 52                                             |
| Legal services, . . . . .                       | 45 00                                                                           | -                                                |
| Printing, . . . . .                             | 4 85                                                                            | -                                                |
| Gas, . . . . .                                  | 20 00                                                                           | 13 36                                            |
| Extra services, . . . . .                       | -                                                                               | 20 00                                            |
|                                                 | \$6,406 90                                                                      | \$4,047 21                                       |
|                                                 |                                                                                 | 6,406 90                                         |
| Total, . . . . .                                |                                                                                 | \$10,454 11                                      |

SAM'L W. ABBOTT,

*Secretary.*

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**REPORT OF DR. C. P. WORCESTER, ANALYST.**

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## REPORT OF DR. C. P. WORCESTER, ANALYST.

Dr. S. W. ABBOTT, *Secretary of the State Board of Health.*

DEAR SIR:—I have the honor to present my report on the analysis of food and drugs for the year ending Sept. 30, 1893.

The work during this year has been done in the room rented by the Board for the purpose, at 994 Washington Street. The laboratory has proved sufficient for the ordinary routine work, but for any investigation involving special apparatus its resources are too limited. The routine analysis this year has been similar to that of previous years.

### MILK.

|                                | Total<br>Milks Col-<br>lected. | Above<br>Standard. | Below<br>Standard. | Per Cent.<br>Below<br>Standard. | Lowest<br>Sample. | Number of<br>Skimmed<br>Milks. |
|--------------------------------|--------------------------------|--------------------|--------------------|---------------------------------|-------------------|--------------------------------|
| Cities, . . . . .              | 1,981                          | 1,001              | 930                | 48.1                            | 7.42              | 18                             |
| Towns, . . . . .               | 639                            | 375                | 264                | 41.3                            | 9.19              | 2                              |
| Suspected producers, . . . . . | 482                            | 169                | 323                | 67.0                            | 4.72              | —                              |
| Miscellaneous, . . . . .       | 21                             | 10                 | 11                 | 52.4                            | —                 | —                              |
| Total milks, . . . . .         | 3,073                          | 1,545              | 1,528              | 49.7                            | 4.72              | 15                             |

The percentage of samples below standard is 49.7, practically the same as that of last year, which was 48.2 per cent.

The relative advantages of the various processes for the analysis of milk have been discussed at great length in the many text-books and in meetings of analysts the world over. For the purpose of determining the total solids there is no readier method that is reasonably accurate than the evaporation of a weighed quantity of milk over steam in flat-bottomed platinum capsules. The determination of the fat by benzine extraction of this dry residue has proved an



It will be seen that under a standard of 13 per cent. throughout the entire year the ratio of samples below the standard would be 61.2 per cent., while with a 12 per cent. standard for the year the ratio would be only 16.3 per cent., so that the relative showing for the year is largely dependent on legislative enactment.

The following tables show the sources of the various samples of milk examined, apportioned among the cities, towns and suspected producers :—

*Milk from Cities.*

| CITIES.                | Total<br>Samples<br>Collected. | Above<br>Standard. | Below<br>Standard. | Per Cent.<br>below<br>Standard. | Total<br>Solids in<br>Lowest<br>Sample. | Number<br>of<br>Skimmed<br>Samples. | Number<br>of<br>Colored<br>Samples. |
|------------------------|--------------------------------|--------------------|--------------------|---------------------------------|-----------------------------------------|-------------------------------------|-------------------------------------|
| Boston, . . . . .      | 191                            | 92                 | 99                 | 52.3                            | 9.66                                    | 3                                   | -                                   |
| Brockton, . . . . .    | 23                             | 16                 | 7                  | 30.4                            | 10.45                                   | -                                   | -                                   |
| Cambridge, . . . . .   | 383                            | 210                | 173                | 45.2                            | 10.27                                   | 3                                   | -                                   |
| Chelsea, . . . . .     | 179                            | 83                 | 96                 | 53.7                            | 10.74                                   | 4                                   | -                                   |
| Everett, . . . . .     | 121                            | 49                 | 72                 | 59.5                            | 10.84                                   | 2                                   | 4                                   |
| Fall River, . . . . .  | 84                             | 50                 | 34                 | 40.4                            | 10.60                                   | -                                   | -                                   |
| Fitchburg, . . . . .   | 12                             | 11                 | 1                  | 8.3                             | 9.50                                    | 3                                   | -                                   |
| Gloucester, . . . . .  | 106                            | 58                 | 48                 | 45.3                            | 8.80                                    | -                                   | 2                                   |
| Haverhill, . . . . .   | 13                             | 6                  | 7                  | 53.8                            | 11.18                                   | -                                   | -                                   |
| Lawrence, . . . . .    | 58                             | 37                 | 21                 | 36.2                            | 11.11                                   | 4                                   | -                                   |
| Malden, . . . . .      | 130                            | 62                 | 68                 | 52.3                            | 10.60                                   | 1                                   | -                                   |
| Marlborough, . . . . . | 10                             | 3                  | 7                  | 70.0                            | 11.65                                   | 2                                   | -                                   |
| Medford, . . . . .     | 130                            | 63                 | 67                 | 51.5                            | 11.10                                   | -                                   | 1                                   |
| Newburyport, . . . . . | 12                             | 7                  | 5                  | 41.6                            | 12.44                                   | -                                   | -                                   |
| Newton, . . . . .      | 92                             | 54                 | 38                 | 41.3                            | 10.52                                   | 1                                   | -                                   |
| North Adams, . . . . . | 13                             | 11                 | 2                  | 15.3                            | 12.08                                   | -                                   | -                                   |
| Quincy, . . . . .      | 44                             | 16                 | 28                 | 63.6                            | 11.15                                   | -                                   | -                                   |
| Salem, . . . . .       | 102                            | 56                 | 46                 | 45.1                            | 9.87                                    | -                                   | -                                   |
| Somerville, . . . . .  | 280                            | 125                | 155                | 51.9                            | 10.08                                   | 1                                   | -                                   |
| Taunton, . . . . .     | 24                             | 18                 | 6                  | 25.0                            | 11.28                                   | -                                   | -                                   |
| Waltham, . . . . .     | 56                             | 27                 | 29                 | 51.7                            | 10.27                                   | -                                   | 3                                   |
| Woburn, . . . . .      | 140                            | 46                 | 94                 | 67.1                            | 9.95                                    | -                                   | 16                                  |
| Worcester, . . . . .   | 22                             | 9                  | 13                 | 59.1                            | 11.66                                   | -                                   | -                                   |
| Totals, . . . . .      | 2,205                          | 1,109              | 1,096              | 49.7                            | 8.80                                    | 24                                  | 26                                  |

## MILK FROM CITIES.

| CITIES.                | Total<br>Milk Col-<br>lected. | Above<br>Standard. | Below<br>Standard. | Per Cent.<br>Below<br>Standard. | Total<br>Solids in<br>Lowest<br>Sample. | Number of<br>Skimmed<br>Milk. |
|------------------------|-------------------------------|--------------------|--------------------|---------------------------------|-----------------------------------------|-------------------------------|
| Boston, . . . . .      | 176                           | 111                | 64                 | 36.6                            | 11.24                                   | 1                             |
| Brockton, . . . . .    | 12                            | 7                  | 5                  | 41.7                            | 11.61                                   | -                             |
| Cambridge, . . . . .   | 323                           | 175                | 148                | 46.8                            | 8.63                                    | 1                             |
| Chelsea, . . . . .     | 131                           | 61                 | 70                 | 53.4                            | 8.62                                    | 6                             |
| Fall River, . . . . .  | 101                           | 67                 | 34                 | 33.6                            | 9.35                                    | -                             |
| Fitchburg, . . . . .   | 24                            | 7                  | 17                 | 70.8                            | 9.40                                    | -                             |
| Gloucester, . . . . .  | 90                            | 27                 | 63                 | 70.0                            | 8.67                                    | -                             |
| Lawrence, . . . . .    | 24                            | 15                 | 9                  | 37.5                            | 9.99                                    | 1                             |
| Lowell, . . . . .      | 12                            | 9                  | 3                  | 25.0                            | 12.03                                   | -                             |
| Lynn, . . . . .        | 141                           | 48                 | 95                 | 67.3                            | 7.42                                    | 1                             |
| Malden, . . . . .      | 148                           | 68                 | 82                 | 55.4                            | 8.93                                    | -                             |
| Marlborough, . . . . . | 8                             | 7                  | 1                  | 12.5                            | 12.63                                   | -                             |
| Newton, . . . . .      | 78                            | 49                 | 29                 | 37.2                            | 9.94                                    | -                             |
| New Bedford, . . . . . | 26                            | 18                 | 8                  | 30.8                            | 11.17                                   | -                             |
| Quincy, . . . . .      | 24                            | 9                  | 15                 | 62.5                            | 10.60                                   | -                             |
| Salem, . . . . .       | 99                            | 58                 | 41                 | 41.4                            | 9.15                                    | -                             |
| Somerville, . . . . .  | 294                           | 134                | 160                | 54.4                            | 9.76                                    | 1                             |
| Taunton, . . . . .     | 56                            | 43                 | 13                 | 23.2                            | 9.82                                    | -                             |
| Waltham, . . . . .     | 40                            | 30                 | 10                 | 25.0                            | 11.42                                   | -                             |
| Woburn, . . . . .      | 81                            | 40                 | 41                 | 50.6                            | 10.26                                   | -                             |
| Worcester, . . . . .   | 44                            | 22                 | 22                 | 50.0                            | 10.82                                   | 2                             |
|                        | 1,981                         | 1,001              | 980                | 48.1                            | 7.42                                    | 13                            |

## MILK FROM TOWNS.

| TOWNS.                         | Total<br>Milk Col-<br>lected. | Above<br>Standard. | Below<br>Standard. | Per Cent.<br>Below<br>Standard. | Total<br>Solids in<br>Lowest<br>Sample. | Number of<br>Skimmed<br>Milk. |
|--------------------------------|-------------------------------|--------------------|--------------------|---------------------------------|-----------------------------------------|-------------------------------|
| Adams, . . . . .               | 12                            | 10                 | 2                  | 16.6                            | 12.11                                   | -                             |
| Brookline, . . . . .           | 83                            | 48                 | 35                 | 42.2                            | 11.83                                   | -                             |
| Canton, . . . . .              | 17                            | 13                 | 4                  | 23.5                            | 9.84                                    | -                             |
| Dedham, . . . . .              | 54                            | 37                 | 17                 | 31.5                            | 10.02                                   | -                             |
| Everett, . . . . .             | 57                            | 29                 | 28                 | 49.1                            | 10.40                                   | -                             |
| Framlingham, . . . . .         | 6                             | 4                  | 2                  | 33.3                            | 11.32                                   | -                             |
| Greenfield, . . . . .          | 12                            | 10                 | 2                  | 16.6                            | 12.50                                   | -                             |
| Hull, . . . . .                | 13                            | 4                  | 9                  | 69.2                            | 10.00                                   | -                             |
| Hyde Park, . . . . .           | 59                            | 27                 | 32                 | 54.2                            | 10.40                                   | -                             |
| Marblehead, . . . . .          | 12                            | 8                  | 4                  | 33.3                            | 9.19                                    | -                             |
| Medford, . . . . .             | 72                            | 30                 | 42                 | 58.3                            | 9.38                                    | -                             |
| Milford, . . . . .             | 12                            | 4                  | 8                  | 66.6                            | 11.80                                   | -                             |
| Natick, . . . . .              | 24                            | 21                 | 3                  | 12.5                            | 12.39                                   | -                             |
| Norwood, . . . . .             | 21                            | 13                 | 8                  | 38.1                            | 9.81                                    | 2                             |
| Orange, . . . . .              | 12                            | 7                  | 5                  | 41.6                            | 10.06                                   | -                             |
| Plymouth, . . . . .            | 4                             | 1                  | 3                  | 75.                             | 11.47                                   | -                             |
| Provincetown, . . . . .        | 40                            | 29                 | 11                 | 27.5                            | 9.28                                    | -                             |
| Randolph, . . . . .            | 10                            | 10                 | 0                  | 0.0                             | 13.40                                   | -                             |
| Revere, . . . . .              | 34                            | 16                 | 18                 | 52.9                            | 10.45                                   | -                             |
| Stoneham, . . . . .            | 16                            | 6                  | 10                 | 62.5                            | 11.80                                   | -                             |
| Stoughton, . . . . .           | 21                            | 16                 | 5                  | 23.8                            | 12.11                                   | -                             |
| Wakefield, . . . . .           | 5                             | 3                  | 2                  | 40.                             | 11.19                                   | -                             |
| Wareham (Onset Bay), . . . . . | 13                            | 9                  | 4                  | 30.7                            | 12.08                                   | -                             |
| Watertown, . . . . .           | 13                            | 5                  | 8                  | 61.5                            | 10.35                                   | -                             |
| Weymouth, . . . . .            | 8                             | 6                  | 2                  | 25.                             | 12.38                                   | -                             |
| Winthrop, . . . . .            | 9                             | 9                  | 0                  | 0.0                             | 12.70                                   | -                             |
|                                | 639                           | 375                | 264                | 41.3                            | 9.19                                    | 2                             |

## MILK FROM SUSPECTED PRODUCERS.

| SUSPECTED PRODUCERS.    | Total<br>Milk Col-<br>lected. | Above<br>Standard. | Below<br>Standard. | Per Cent.<br>Below<br>Standard. | Total Solids<br>in Lowest<br>Sample. |
|-------------------------|-------------------------------|--------------------|--------------------|---------------------------------|--------------------------------------|
| Acton, . . . . .        | 15                            | 4                  | 11                 | 73.3                            | 10.46                                |
| Berlin, . . . . .       | 15                            | 7                  | 8                  | 53.3                            | 9.23                                 |
| Billerica, . . . . .    | 19                            | 12                 | 7                  | 36.8                            | 12.14                                |
| Brookfield, . . . . .   | 5                             | 0                  | 5                  | 100.                            | 9.31                                 |
| Carlisle, . . . . .     | 5                             | 1                  | 4                  | 80.                             | -                                    |
| Charlton, . . . . .     | 39                            | 27                 | 12                 | 30.8                            | 4.72                                 |
| Chelmsford, . . . . .   | 19                            | 13                 | 6                  | 31.6                            | 9.88                                 |
| Concord, . . . . .      | 4                             | 0                  | 4                  | 100.                            | 11.70                                |
| Dover, . . . . .        | 12                            | 6                  | 6                  | 50.                             | 10.40                                |
| Frammingham, . . . . .  | 6                             | 0                  | 6                  | 100.                            | 9.86                                 |
| Grafton, . . . . .      | 12                            | 0                  | 12                 | 100.                            | 11.57                                |
| Holliston, . . . . .    | 4                             | 0                  | 4                  | 100.                            | 10.04                                |
| Hopedale, . . . . .     | 4                             | 0                  | 4                  | 100.                            | 9.71                                 |
| Hopkinton, . . . . .    | 8                             | 4                  | 4                  | 50.                             | 11.14                                |
| Lincoln, . . . . .      | 15                            | 5                  | 10                 | 66.6                            | 11.50                                |
| Littleton, . . . . .    | 22                            | 5                  | 17                 | 77.3                            | 11.43                                |
| Maynard, . . . . .      | 6                             | 0                  | 6                  | 100.                            | 11.15                                |
| Medfield, . . . . .     | 46                            | 10                 | 36                 | 78.4                            | 10.40                                |
| Medway, . . . . .       | 3                             | 2                  | 1                  | 33.3                            | 12.58                                |
| Mendon, . . . . .       | 13                            | 4                  | 9                  | 69.2                            | 10.21                                |
| Millis, . . . . .       | 9                             | 3                  | 6                  | 66.6                            | 11.00                                |
| Norfolk, . . . . .      | 3                             | 3                  | 0                  | 0.0                             | 13.40                                |
| Northborough, . . . . . | 12                            | 5                  | 7                  | 58.3                            | 11.88                                |
| Norwood, . . . . .      | 28                            | 11                 | 17                 | 60.7                            | 10.63                                |
| Salisbury, . . . . .    | 18                            | 8                  | 10                 | 55.5                            | 9.45                                 |
| Shirley, . . . . .      | 6                             | 0                  | 6                  | 100.                            | 11.31                                |
| Southborough, . . . . . | 5                             | 3                  | 2                  | 40.                             | 9.02                                 |
| Sutton, . . . . .       | 10                            | 1                  | 9                  | 90.                             | 9.29                                 |
| Upton, . . . . .        | 17                            | 1                  | 16                 | 94.1                            | 10.22                                |
| Waltham, . . . . .      | 4                             | 2                  | 2                  | 50.                             | 12.52                                |
| Walpole, . . . . .      | 21                            | 4                  | 17                 | 80.9                            | 8.48                                 |
| Wenham, . . . . .       | 11                            | 2                  | 9                  | 81.8                            | 10.33                                |
| Westborough, . . . . .  | 34                            | 4                  | 30                 | 88.2                            | 11.35                                |
| Westport, . . . . .     | 20                            | 10                 | 10                 | 50.                             | 10.94                                |
| Wrentham, . . . . .     | 12                            | 2                  | 10                 | 83.3                            | 10.21                                |
|                         | 482                           | 159                | 323                | 67.0                            | 4.72                                 |

The comparison of the quality of samples by months is of some interest in view of the efforts made to reduce the standard during the spring and summer months.

For this purpose the following tables have been prepared, showing the percentage of adulteration during the months of the preceding as well as of the present year, with both 12 and 13 per cent. assumed as a standard through the whole year : —

QUALITY OF MILK BY MONTHS. YEAR ENDING SEPT. 30, 1892.

| MONTHS.              | Total<br>Milk Col-<br>lected. | Above 13<br>Per Cent. | Below 13<br>Per Cent. | Below 12<br>Per Cent. | Per Cent. of<br>Adulteration,<br>13 Per Cent.<br>Standard. | Per Cent. of<br>Adulteration,<br>12 Per Cent.<br>Standard. |
|----------------------|-------------------------------|-----------------------|-----------------------|-----------------------|------------------------------------------------------------|------------------------------------------------------------|
| October, . . . . .   | 305                           | 164                   | 151                   | 42                    | 49.5                                                       | 13.7                                                       |
| November, . . . . .  | 197                           | 104                   | 93                    | 25                    | 47.2                                                       | 12.6                                                       |
| December, . . . . .  | 142                           | 81                    | 61                    | 16                    | 42.9                                                       | 11.2                                                       |
| January, . . . . .   | 163                           | 102                   | 61                    | 8                     | 37.3                                                       | 4.9                                                        |
| February, . . . . .  | 240                           | 119                   | 121                   | 30                    | 60.4                                                       | 12.5                                                       |
| March, . . . . .     | 239                           | 98                    | 141                   | 44                    | 59.                                                        | 18.4                                                       |
| April, . . . . .     | 336                           | 151                   | 185                   | 49                    | 55.                                                        | 14.6                                                       |
| May, . . . . .       | 293                           | 125                   | 165                   | 43                    | 56.3                                                       | 14.6                                                       |
| June, . . . . .      | 234                           | 91                    | 162                   | 43                    | 63.8                                                       | 16.9                                                       |
| July, . . . . .      | 253                           | 89                    | 164                   | 64                    | 64.8                                                       | 25.2                                                       |
| August, . . . . .    | 238                           | 68                    | 170                   | 42                    | 71.4                                                       | 17.6                                                       |
| September, . . . . . | 350                           | 128                   | 231                   | 63                    | 64.3                                                       | 17.6                                                       |
| Average, . . . . .   | -                             | -                     | -                     | -                     | 55.2                                                       | 15.                                                        |

QUALITY OF MILK BY MONTHS. YEAR ENDING SEPT. 30, 1893.

| MONTHS.              | Total<br>Milk Col-<br>lected. | Above 13<br>Per Cent. | Below 13<br>Per Cent. | Below 12<br>Per Cent. | Per Cent. of<br>Adulteration,<br>13 Per Cent.<br>Standard. | Per Cent. of<br>Adulteration,<br>12 Per Cent.<br>Standard. |
|----------------------|-------------------------------|-----------------------|-----------------------|-----------------------|------------------------------------------------------------|------------------------------------------------------------|
| October, . . . . .   | 272                           | 146                   | 126                   | 28                    | 46.3                                                       | 10.3                                                       |
| November, . . . . .  | 304                           | 187                   | 117                   | 37                    | 38.4                                                       | 12.1                                                       |
| December, . . . . .  | 260                           | 117                   | 143                   | 49                    | 65.                                                        | 18.8                                                       |
| January, . . . . .   | 111                           | 51                    | 60                    | 17                    | 54.                                                        | 15.3                                                       |
| February, . . . . .  | 109                           | 37                    | 72                    | 25                    | 66.                                                        | 22.9                                                       |
| March, . . . . .     | 231                           | 103                   | 128                   | 40                    | 55.4                                                       | 17.3                                                       |
| April, . . . . .     | 257                           | 120                   | 137                   | 50                    | 53.2                                                       | 19.4                                                       |
| May, . . . . .       | 250                           | 86                    | 165                   | 60                    | 66.                                                        | 24.                                                        |
| June, . . . . .      | 294                           | 94                    | 200                   | 32                    | 68.                                                        | 10.9                                                       |
| July, . . . . .      | 298                           | 91                    | 207                   | 85                    | 69.4                                                       | 28.5                                                       |
| August, . . . . .    | 423                           | 134                   | 289                   | 122                   | 68.3                                                       | 28.8                                                       |
| September, . . . . . | 264                           | 107                   | 157                   | 41                    | 59.5                                                       | 15.5                                                       |
| Average, . . . . .   | -                             | -                     | -                     | -                     | 58.5                                                       | 18.6                                                       |

*Condensed Milk.*

Samples of condensed milk and so-called "evaporated cream" were analyzed for total solids and fat with the following results, the fat being obtained by benzine extraction : —

| INSPECTORS' NUMBER. | Brand.                 | Character of Sample. | Per Cent. Solids. | Per Cent. Solids not Fat. | Per Cent. Fat. | Per Cent. Water. |
|---------------------|------------------------|----------------------|-------------------|---------------------------|----------------|------------------|
| 13570 . .           | St. Charles, . . .     | Evaporated cream, .  | 31.87             | 26.83                     | 5.04           | 65.13            |
| 13572 . .           | Highland, . . .        | " "                  | 31.00             | 25.70                     | 5.90           | 68.40            |
| 1024 . .            | St. Charles, . . .     | " "                  | 31.09             | 26.74                     | 4.35           | 68.91            |
| 15431 . .           | Baby, . . .            | Condensed milk, .    | 67.20             | 59.70                     | 7.50           | 32.80            |
| 1988 . .            | J. B. Smith, . . .     | " "                  | 75.43             | 63.66                     | 11.78          | 24.57            |
| 8406 . .            | Newport, . . .         | " "                  | 68.32             | 61.10                     | 7.22           | 31.68            |
| 83 . .              | Puritan, . . .         | " "                  | 78.35             | 68.                       | 10.35          | 21.65            |
| 127 . .             | Maine Jersey, . . .    | " "                  | 69.02             | 62.75                     | 6.27           | 30.98            |
| 1063 . .            | Full Weight, . . .     | " "                  | 74.45             | 67.16                     | 7.29           | 25.55            |
| 1935 . .            | Sovereign, . . .       | " "                  | 71.75             | 65.00                     | 6.75           | 28.25            |
| 2199 . .            | Winner, . . .          | " "                  | 68.00             | 62.00                     | 6.00           | 32.00            |
| 2333 . .            | Fisherman's, . . .     | " "                  | 69.10             | 63.07                     | 6.03           | 30.96            |
| 2613 . .            | Champion, . . .        | " "                  | 74.20             | 65.50                     | 8.70           | 25.80            |
| 2875 . .            | Twitchei Champlin Co., | " "                  | 72.20             | 59.80                     | 12.40          | 27.80            |
| 3123 . .            | Dime, . . .            | " "                  | 72.10             | 60.00                     | 12.10          | 27.90            |

*Cheese.*

Seventy-three samples of cheese have been examined and no case of fraudulent adulteration has been found. A series of forty-one samples were obtained at different times from the poorer quarters of Boston, and were analyzed immediately after purchase, before any appreciable loss of water by evaporation could take place, with the following results : —

| INSPECTORS' NUMBER. | Per Cent. Solids. | Per Cent. Fat. | Per Cent. Solids Not Fat. | Per Cent. Water. | Per Cent. Fat in Total Solids. | Price per Pound. |
|---------------------|-------------------|----------------|---------------------------|------------------|--------------------------------|------------------|
| 5241 . . . . .      | 66.04             | 38.            | 28.04                     | 33.96            | 57.54                          | Cents.<br>17     |
| 5239 . . . . .      | 66.06             | 37.            | 29.06                     | 33.94            | 56.01                          | 16               |
| 5237 . . . . .      | 62.36             | 26.            | 36.36                     | 37.64            | 41.69                          | 10               |
| 5235 . . . . .      | 66.18             | 34.            | 32.18                     | 33.82            | 51.22                          | 18               |
| 5223 . . . . .      | 66.00             | 35.            | 31.00                     | 34.00            | 53.03                          | 16               |

| INSPECTORS' NUMBER.  | Per Cent.<br>Solids. | Per Cent.<br>Fat. | Per Cent.<br>Solids<br>Not Fat. | Per Cent.<br>Water. | Per Cent.<br>Fat in<br>Total Solids. | Price per<br>Pound. |
|----------------------|----------------------|-------------------|---------------------------------|---------------------|--------------------------------------|---------------------|
|                      |                      |                   |                                 |                     |                                      | Cents.<br>16        |
| 5231 . . . . .       | 68.14                | 38.               | 30.14                           | 31.86               | 55.77                                | 16                  |
| 5229 . . . . .       | 62.14                | 32.               | 30.14                           | 37.86               | 51.49                                | 16                  |
| 5227 . . . . .       | 66.60                | 35.               | 31.60                           | 33.40               | 52.55                                | 16                  |
| 5325 . . . . .       | 64.19                | 34.               | 30.19                           | 35.81               | 52.97                                | 16                  |
| 5327 . . . . .       | 67.26                | 37.               | 30.26                           | 32.74               | 55.01                                | 16                  |
| 5331 . . . . .       | 66.76                | 35.               | 31.76                           | 33.24               | 52.41                                | 16                  |
| 5333 . . . . .       | 66.24                | 37.               | 29.24                           | 33.76               | 55.85                                | 16                  |
| 5335 . . . . .       | 68.84                | 38.               | 30.84                           | 31.16               | 55.20                                | 18                  |
| 5323 . . . . .       | 64.32                | 35.               | 29.32                           | 35.68               | 54.41                                | 16                  |
| 5821 . . . . .       | 60.36                | 35.               | 25.36                           | 39.64               | 57.98                                | 16                  |
| 5815 . . . . .       | 72.30                | 37.               | 35.30                           | 27.70               | 51.17                                | 16                  |
| 5817 . . . . .       | 60.40                | 34.               | 26.40                           | 39.60               | 56.29                                | 16                  |
| 5819 . . . . .       | 65.00                | 36.               | 29.00                           | 35.00               | 55.38                                | 16                  |
| 5811 . . . . .       | 63.72                | 35.               | 28.72                           | 36.28               | 54.92                                | 16                  |
| 5809 . . . . .       | 70.12                | 37.               | 33.12                           | 29.88               | 52.76                                | 16                  |
| 5813 . . . . .       | 70.37                | 32.               | 38.37                           | 29.63               | 45.47                                | 16                  |
| 5827 . . . . .       | 69.10                | 39.               | 30.10                           | 31.90               | 56.44                                | 16                  |
| 5825 . . . . .       | 72.52                | 40.               | 32.52                           | 29.48               | 55.15                                | 16                  |
| 5829 . . . . .       | 68.93                | 38.               | 30.93                           | 31.07               | 55.13                                | 16                  |
| 5831 . . . . .       | 62.88                | 36.               | 26.88                           | 37.12               | 57.23                                | 16                  |
| 5837 . . . . .       | 59.43                | 35.               | 24.43                           | 40.57               | 58.89                                | 16                  |
| 5835 . . . . .       | 62.09                | 32.               | 30.09                           | 37.91               | 51.53                                | 16                  |
| 5833 . . . . .       | 55.89                | 29.               | 26.89                           | 44.11               | 51.89                                | 16                  |
| 5839 . . . . .       | 67.92                | 40.               | 27.92                           | 32.08               | 58.89                                | 16                  |
| 5903 . . . . .       | 67.94                | 35.               | 32.94                           | 32.06               | 51.51                                | 16                  |
| 5889 . . . . .       | 70.49                | 32.               | 38.49                           | 29.51               | 45.39                                | 16                  |
| 5895 . . . . .       | 70.31                | 37.               | 33.31                           | 29.69               | 52.62                                | 16                  |
| 6573 . . . . .       | 69.99                | 39.               | 30.99                           | 30.01               | 55.72                                | 16                  |
| 5901 . . . . .       | 69.83                | 36.               | 33.83                           | 30.17               | 51.55                                | 16                  |
| 5897 . . . . .       | 69.14                | 36.               | 33.14                           | 30.86               | 52.05                                | 16                  |
| 5899 . . . . .       | 69.01                | 27.               | 42.01                           | 30.99               | 39.12                                | 16                  |
| 5329* . . . . .      | 44.43                | 3.                | 41.43                           | 55.57               | 6.75                                 | 14                  |
| 5337† . . . . .      | 44.26                | 26.               | 18.26                           | 55.74               | 58.74                                | -                   |
| 5330‡ . . . . .      | 61.30                | 45.               | 16.30                           | 38.70               | 73.49                                | 20                  |
| 17279† . . . . .     | 44.70                | 5.2               | 39.50                           | 55.30               | 11.63                                | -                   |
| Average, § . . . . . | 66.35                | 35.               | 31.35                           | 33.65               | 52.75                                | -                   |

\* Skimmed milk cheese.

† Neufchatel cheese.

‡ Cream cheese.

§ Average is exclusive of last four samples.

It will be noticed that with few exceptions the uniform retail price of whole-milk cheese was found to be sixteen cents per pound. The exceptions were the skimmed-milk cheeses and remnant lots of poor quality which were cheaper and the extra cream cheeses which were more expensive. This means two-thirds of a pound of milk solids for sixteen cents, or one pound for twenty-four cents. Now, twenty-four cents will buy at retail, as a rule, four quarts of standard milk, which contain approximately one pound of milk solids. Weight for weight, then (water excluded), cheese and milk are sold practically at the same rate. It should be added, however, that nearly one-third of the milk solids is sugar, a much cheaper element of food than the fat and proteids which are in greater proportion in cheese. The percentage of fat determined by the Babcock process in terms of solids averaged 53 per cent., a somewhat high ratio. Of standard milk the fat is 28 per cent. in terms of the solids, the smaller ratio being due chiefly to the excess of sugar in the milk solids.

#### *Butter.*

In but one instance has the fraudulent substitution of oleomargarine for butter been found. Four hundred and seventeen samples of butter have been analyzed and twenty-four of oleomargarine.

#### *Bread.*

Fifty-nine samples of bread, chiefly of cheap white bread, were collected from the poorer classes of bakeries and grocers' shops in order to ascertain what sort of bread is furnished to the poorer classes who usually depend on the "corner grocery" for their supply.

Inspection showed, as a rule, loaves which were not far from the standard "home-baked family loaf." They showed, as a rule, a thorough baking, though there were not a few exceptions to this rule; they were well "raised," had a good crumbling fracture, were not tough and soggy, nor, on the other hand, were they over-raised, with a dry and spongy texture. The majority had the sweet, agreeable odor and taste described as the "nutty flavor" characteristic of a well-made loaf. In a number of instances, however, there was distinctly perceptible a musty flavor, amounting in some cases to a downright sour odor and taste. This sourness seems, at least in part, to be due to a bacterial growth attended by

the production of lactic acid or of acid salts. At what stage in the process of manufacture this incipient decomposition has taken place it is impossible to determine without a careful investigation of each step in the process of making every loaf.

The souring of bread may usually be traced to poor materials or to uncleanness in the manufacture. Chief among the unsound materials which may contribute toward this sourness are usually noted damaged flour and decomposing yeast. So far as has been investigated the use of unsound flour is not practiced in this part of the country. The yeast generally used is of excellent quality. It is a stiff, smooth mash, put up usually in small tin-foiled cakes, and kept in a cool place. Under the microscope this mash is seen to be composed of about equal parts of potato or corn starch and yeast spores. It has a distinct yeasty odor, and but rarely is it strongly acid in reaction. To the almost universal use of good sweet yeast of this variety in the small bakeries is doubtless due no small share in the great improvement in quality of the common baker's loaf of today as compared with that of ten or more years ago.

A vigorous, pure yeast which will "raise" quickly is a great preventive against sour bread, for not only is it comparatively free from the germs and products of lactic acid decomposition, but by doing its work quickly it enables the baker to check the fermentation or "raising" process before the lactic acid or sour decomposition is reached.

The degree of sourness of the samples of bread examined has been roughly measured and compared by titrating or neutralizing 10 grammes of the crumb, rubbed up with water, with a decinormal soda solution. To neutralize the acidity of 10 grammes of the normally sweet loaf an average of 2 cubic centimeters of the soda solution was required. This would correspond to 0.72 grammes of lactic acid per loaf of an average weight of about 400 grammes. The loaf exhibiting the maximum sourness or acidity required 10 cubic centimeters per 10 grammes of bread corresponding to 11.61 grammes of lactic acid per loaf of 1,291 grammes.

The so-called black bread (rye bread), which finds a ready sale among our foreign population, is notably sour and heavy, and apparently its sourness is valued by this class. A sour bread is undesirable, not only because it is unpalatable but also because of the bacterial processes of decomposition which this acidity indicates, and which may seriously interfere with digestion.



*Bread.*

| INSPECTOR'S<br>NUMBER. | Weight of Loaf in<br>Grammes. | Percentage of Water. | Percentage of Solids. | Percentage of Ash in<br>Terms of Solids. | Acidity, Cubic Centi-<br>meters of .5 per cent.<br>Sodium Bicarbonate<br>Solution Required<br>to Neutralize 10<br>Grams. Fresh Bread. | Price of Loaf in<br>Cents. | Description.                                |
|------------------------|-------------------------------|----------------------|-----------------------|------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|----------------------------|---------------------------------------------|
| 4761 . . .             | 490                           | 42                   | 58                    | 1.03                                     | 2.5                                                                                                                                   | 5                          | White.                                      |
| 4763 . . .             | 434                           | 33                   | 67                    | 1.10                                     | 2.7                                                                                                                                   | 5                          | White.                                      |
| 4765 . . .             | 340                           | 43                   | 57                    | 0.80                                     | 2.2                                                                                                                                   | 5                          | White.                                      |
| 4793 . . .             | 590                           | 41                   | 59                    | 0.90                                     | 2.7                                                                                                                                   | 10                         | White.                                      |
| 4795 . . .             | -                             | 43                   | 57                    | 1.30                                     | 3.0                                                                                                                                   | 5                          | White.                                      |
| 4899 . . .             | 417                           | 42                   | 58                    | 0.95                                     | -                                                                                                                                     | 5                          | White, with caraway seed.                   |
| 6245 . . .             | 390                           | 45                   | 55                    | 1.90                                     | 2.6                                                                                                                                   | 5                          | White.                                      |
| 6253 . . .             | 457                           | 43                   | 57                    | 0.92                                     | -                                                                                                                                     | 5                          | White.                                      |
| 6247 . . .             | 373                           | 40                   | 60                    | 1.44                                     | 4.3                                                                                                                                   | 4                          | White, over-raised, dry and<br>spongy.      |
| 6249 . . .             | 387                           | 39                   | 61                    | 1.94                                     | -                                                                                                                                     | 5                          | White, over-raised.                         |
| 6251 . . .             | 406                           | 42                   | 58                    | 1.18                                     | 3.5                                                                                                                                   | 5                          | White.                                      |
| 6253 . . .             | 400                           | 41                   | 59                    | 1.23                                     | 1.8                                                                                                                                   | 5                          | White, from "N. E. kitchen."                |
| 6691 . . .             | 464                           | 42                   | 58                    | 0.63                                     | -                                                                                                                                     | 5                          | White, underdone.                           |
| 6693 . . .             | 410                           | 44                   | 56                    | 1.05                                     | -                                                                                                                                     | 5                          | White.                                      |
| 6695 . . .             | 387                           | 43                   | 57                    | 1.40                                     | 3.3                                                                                                                                   | 4                          | White, over-raised, spongy.                 |
| 6697 . . .             | 431                           | 43                   | 57                    | 0.83                                     | 3.3                                                                                                                                   | 5                          | White.                                      |
| 6699 . . .             | 450                           | 42                   | 58                    | 1.09                                     | 3.0                                                                                                                                   | 5                          | White.                                      |
| 6701 . . .             | 387                           | 41                   | 59                    | 1.16                                     | 1.9                                                                                                                                   | 5                          | White, "milk loaf."                         |
| 6703 . . .             | 320                           | 42                   | 58                    | 1.40                                     | 2.1                                                                                                                                   | 4                          | White.                                      |
| 6705 . . .             | 502                           | 43                   | 57                    | 1.83                                     | 6.2                                                                                                                                   | 4                          | White, glazed roll loaf, tough<br>and sour. |
| 6707 . . .             | 415                           | 43                   | 57                    | 0.65                                     | 1.3                                                                                                                                   | 5                          | White, underdone.                           |
| 6709 . . .             | 450                           | 43                   | 57                    | 0.85                                     | 1.4                                                                                                                                   | 5                          | White, underdone.                           |
| 6713 . . .             | 495                           | 42                   | 58                    | 0.95                                     | 1.7                                                                                                                                   | 5                          | White, "shortened."                         |
| 6715 . . .             | 422                           | 42                   | 58                    | 1.27                                     | -                                                                                                                                     | 5                          | White.                                      |
| 6717 . . .             | 415                           | 42                   | 58                    | 1.00                                     | -                                                                                                                                     | 5                          | White.                                      |
| 6719 . . .             | 654                           | 44                   | 56                    | 1.00                                     | 1.5                                                                                                                                   | 10                         | White, "milk loaf."                         |
| 6721 . . .             | 420                           | 42                   | 58                    | 1.15                                     | 1.8                                                                                                                                   | 5                          | White.                                      |
| 6723 . . .             | 547                           | 39                   | 61                    | 0.55                                     | 3.2                                                                                                                                   | 5                          | White, over-raised, underdone.              |
| 6725 . . .             | 422                           | 42                   | 58                    | 0.92                                     | 2.1                                                                                                                                   | 5                          | White.                                      |
| 6727 . . .             | 382                           | 42                   | 58                    | 0.80                                     | 1.7                                                                                                                                   | 5                          | White.                                      |
| 6511 . . .             | 264                           | 44                   | 56                    | 0.85                                     | 1.4                                                                                                                                   | 4                          | White, "French loaf."                       |
| 6509 . . .             | 461                           | 41                   | 59                    | 0.64                                     | 2.4                                                                                                                                   | 5                          | White.                                      |
| 6507 . . .             | 441                           | 42                   | 58                    | 0.60                                     | 1.9                                                                                                                                   | 5                          | White, underdone.                           |
| 6505 . . .             | 653                           | 44                   | 56                    | 1.60                                     | 7.6                                                                                                                                   | 6                          | White, yellowish, sour.                     |

*Bread—Concluded.*

| INSPECTORS' NUMBER. | Weight of Loaf in Grammes. | Percentage of Water. | Percentage of Solids. | Percentage of Ash in Terms of Solids. | Acidity. Cubic Centimeters of Soda Solution Required to Neutralize 10 Gms. Fresh Bread. | Price of Loaf in Cents. | Description.                 |
|---------------------|----------------------------|----------------------|-----------------------|---------------------------------------|-----------------------------------------------------------------------------------------|-------------------------|------------------------------|
| 6503 . . .          | 422                        | 42                   | 58                    | 0.75                                  | 3.0                                                                                     | 5                       | White.                       |
| 6501 . . .          | 420                        | 43                   | 57                    | 1.60                                  | 1.9                                                                                     | 5                       | White, underdone.            |
| 6499 . . .          | 128                        | 41                   | 59                    | 1.17                                  | 2.5                                                                                     | 5                       | White.                       |
| 6497 . . .          | 126                        | 43                   | 57                    | 1.65                                  | 2.0                                                                                     | 5                       | White.                       |
| 6495 . . .          | 454                        | 43                   | 57                    | 0.77                                  | 1.9                                                                                     | 5                       | White.                       |
| 6493 . . .          | 433                        | 43                   | 57                    | 0.80                                  | 3.0                                                                                     | 5                       | White.                       |
| 6491 . . .          | 448                        | 42                   | 58                    | 0.97                                  | 3.0                                                                                     | 5                       | White.                       |
| 6489 . . .          | 418                        | 42                   | 58                    | 1.10                                  | 2.5                                                                                     | 5                       | White, "French roll."        |
| 6611 . . .          | 477                        | 42                   | 58                    | 1.50                                  | 3.1                                                                                     | 5                       | White, soggy.                |
| 6613 . . .          | 432                        | 44                   | 56                    | 0.95                                  | 1.9                                                                                     | 5                       | White, underdone.            |
| 6515 . . .          | 376                        | 41                   | 59                    | 1.25                                  | 4.2                                                                                     | 5                       | Graham.                      |
| 6513 . . .          | 418                        | 43                   | 57                    | 1.04                                  | 2.1                                                                                     | 5                       | Graham.                      |
| 6517 . . .          | 407                        | 40                   | 60                    | 1.46                                  | 2.3                                                                                     | 5                       | Graham.                      |
| 6519 . . .          | 367                        | 40                   | 60                    | 0.96                                  | 3.6                                                                                     | 5                       | Graham, over-raised, spongy. |
| 6711 . . .          | 435                        | 42                   | 58                    | 1.55                                  | 2.2                                                                                     | 5                       | Graham.                      |
| 5423 . . .          | 500                        | 45                   | 55                    | 1.45                                  | -                                                                                       | 10                      | Graham.                      |
| 4899 . . .          | 445                        | 40                   | 60                    | 1.10                                  | 3.5                                                                                     | 5                       | Graham.                      |
| 5425 . . .          | 507                        | 45                   | 55                    | 1.20                                  | -                                                                                       | 10                      | Whole wheat bread.           |
| 5429 . . .          | 445                        | 47                   | 53                    | 2.20                                  | -                                                                                       | 10                      | "Diabetic" bread.            |
| 4910 . . .          | 194                        | 48                   | 52                    | 1.15                                  | 1.7                                                                                     | 5                       | "Muffins."                   |
| 4759 . . .          | 1291                       | 47                   | 53                    | 2.13                                  | 10.0                                                                                    | 8                       | "Black bread" (rye).         |
| 5427 . . .          | 550                        | 47                   | 53                    | 2.20                                  | -                                                                                       | 10                      | "Black bread."               |
| 4899 . . .          | 417                        | 42                   | 58                    | 0.95                                  | -                                                                                       | 5                       | "Seed bread."                |
| 5421 . . .          | 500                        | 48                   | 52                    | 3.50                                  | -                                                                                       | 10                      | Brown bread.                 |
| 5429 . . .          | 110                        | 8                    | 92                    | 1.94                                  | -                                                                                       | 10                      | "Knacker-brod."              |

Average weight of loaf of white bread is 404 grammes. Usual price is five cents. Average percentage of water of crumb is 42 per cent.

*Spices.*

The microscopic examination of over 1,400 samples of ground spices resulted in the discovery of 189, or 14 per cent. of adulterated samples.

*Allspice.*

Adulteration, 5 per cent. Adulterants found were wheat, corn, ginger and nut shells.

*Cassia.*

Adulteration, 7 per cent. Adulterants found were ginger, bark of some variety, wheat, pease, sawdust and nut shells. The worst specimen contained 75 per cent. of wheat.

*Cayenne.*

Adulteration, 38 per cent. Adulterants found were corn, wheat, ginger, nut shells and turmeric. The worst specimen contained 90 per cent. of wheat, corn, turmeric and cocoanut shells. Many of these samples were purchased as "capsicum" from drug stores, and in these instances the percentage of adulteration was higher than the average.

*Cloves.*

Adulteration, 13 per cent. Adulterants found were corn, wheat, allspice, nut shells, pease, ginger, pepper, charcoal, dirt, turmeric and clove stems. The worst specimen contained 70 per cent. of nut shells, pease and ginger.

*Ginger.*

Adulteration, 7 per cent. Adulterants found were corn, wheat, rice and turmeric. The worst specimen contained 40 per cent. of corn and turmeric.

*Mace.*

The only adulteration found was the apparently accidental admixture of other spices in one instance.

*Mustard.*

Adulteration, 27 per cent. Adulterants found were wheat, corn, rice, cayenne, mustard hulls, tapioca and turmeric, the latter being added for color both in the ground form and in the form of an extract. The worst specimen contained but a small trace of mustard, the other constituents being the first four of the above-named adulterants, colored with turmeric.

*Nutmeg.*

No adulteration found.

*Pepper.*

Adulteration, 11 per cent. Adulterants found were wheat, buckwheat, corn, sawdust, cayenne, nutshells and charcoal. The worst specimen contained 90 per cent. of wheat, buckwheat and cayenne.

*Baking Powder.*

Of eight brands of baking powder examined, six contained alum.

*Canned Goods.*

Of nineteen samples of canned goods of various kinds, none were found to contain any harmful preservative or metallic poison.

*Chocolate.*

No adulteration was found in the five samples submitted.

*Confectionery.*

Of the fifty-nine samples examined, all but two were composed of edible and non-injurious constituents, such as cane sugar, glucose, and wheat, corn and potato starch. Two samples contained paraffin in considerable amount and turpentine, which was added doubtless under the name of "Essence of Lemon."

*Coffee.*

Adulteration, 30 per cent. Adulterants found were chicory, pease, wheat, wood, charcoal and dried grains composed of ground pea hulls and molasses. The worst case of adulteration contained 50 per cent. of pease and chicory, while a "compound coffee" was found to contain no coffee whatever. A coffee substitute and adulterant was found to consist of small brown pellets of about the size of coffee beans, but composed of wheat mash, mixed with a red oxide of iron for a color, and roasted.

*Cream of Tartar.*

Adulteration, 3 per cent. Adulterants found were gypsum, corn starch and phosphate of calcium. The adulteration of cream of tartar is now comparatively rare. The worst sample contained 75 per cent. of calcium phosphate and corn, while a "compound cream of tartar" was found to contain no cream of tartar whatever.

*Honey.*

Adulteration, 14 per cent. The only adulterant found was glucose syrup, which was found in varying amounts up to 40 per cent. The analysis of honey, sugars and syrups is made by means of the polariscope.

*Molasses.*

Adulteration, 11 per cent. The only adulterant found was glucose syrup, which was present in one instance to the extent of 40 per cent.

*Maple Syrup.*

Adulteration, 43 per cent. Adulterants found were cane sugar other than maple and glucose. The worst specimen was a so-called "Vermont Maple Syrup," containing 58 per cent. of glucose syrup.

*Maple Sugar.*

Adulteration, 34 per cent. The adulterant found was a crude molasses sugar, which chemically is nearly identical with maple sugar, but whose flavor is totally different.

*Syrup.*

Only one sample of the fifteen submitted was found to be adulterated, but that contained 50 per cent. of glucose.

*Lard.*

Adulteration, 28 per cent. The adulterants found were cotton-seed oil and tallow.

*Tea.*

None was found to contain other than genuine tea leaves, and but one sample contained too much mineral matter indicating spent leaves. The rigid examination of teas at various ports of entry by government inspectors regularly appointed for that purpose has resulted in practically shutting out spurious teas from our market.

*Vinegar.*

Adulteration, 34 per cent. Any failure to conform to the legal standard of 4.5 per cent. of acetic acid and 2 per cent. of apple solids constitutes adulteration. Samples may contain too little acetic acid

either from insufficient fermentation of the cider or from dilution with water. An insufficiency of apple solids indicates watering, and the substitution of other solids indicates that the vinegar is made at least in part by the fermentation of materials other than cider, — notably molasses. The greater number of adulterated samples fell but slightly below the standard.

### *Olive Oil.*

Adulteration, 26 per cent. The adulterant found was cotton-seed oil. Many of the cotton-seed oil substitutes for olive are now labeled "sweet oil" or "salad oil," terms of such an indefinite significance that technically there is no deception.

### *Miscellaneous.*

Of 116 samples of a miscellaneous description 24 were found not of good quality. Of this number were samples of *pickles* containing notable quantities of alum; *dried apples* containing considerable traces of zinc; *catsup* containing salicylic acid; *fruit syrups* containing salicylic acid, in some instances to the extent of 0.47 per cent.; *salt fish* preserved with boracic acid.

Among the novelties of this class was a sample of "kustard" which proved to be a mixture of corn starch and salt flavored with coumarin.

### *Summary of Food Statistics.*

|                    | Genuine. | Adulterated. | Total. |                  | Genuine. | Adulterated. | Total. |
|--------------------|----------|--------------|--------|------------------|----------|--------------|--------|
| Allspice, . . .    | 92       | 5            | 97     | Honey, . . .     | 46       | 8            | 54     |
| Baking powder, .   | 2        | 6            | 8      | Lard, . . .      | 15       | 6            | 21     |
| Bread, . . .       | 59       | 0            | 59     | Mace, . . .      | 56       | 1            | 57     |
| Butter, . . .      | 417      | 24           | 441    | Maple sugar, . . | 28       | 15           | 43     |
| Canned goods, .    | 19       | 0            | 19     | Maple syrup, . . | 17       | 13           | 30     |
| Cassia, . . .      | 185      | 14           | 199    | Miscellaneous, . | 116      | 24           | 140    |
| Cayenne, . . .     | 40       | 25           | 65     | Molasses, . . .  | 136      | 17           | 153    |
| Cheese, . . .      | 73       | 0            | 73     | Mustard, . . .   | 174      | 64           | 238    |
| Chocolate, . . .   | 5        | 0            | 5      | Nutmeg, . . .    | 2        | 0            | 2      |
| Cloves, . . .      | 190      | 28           | 218    | Olive oil, . . . | 17       | 6            | 23     |
| Coffee, . . .      | 49       | 21           | 70     | Pepper, . . .    | 289      | 36           | 325    |
| Confectionery, .   | 59       | 2            | 61     | Syrup, . . .     | 14       | 1            | 15     |
| Cream of tartar, . | 353      | 13           | 366    | Tea, . . .       | 59       | 1            | 60     |
| Ginger, . . .      | 193      | 16           | 209    | Vinegar, . . .   | 58       | 31           | 89     |

## DRUGS.

Of this class, 327 samples were examined. Ninety-nine proved to be not of Pharmacopœal quality.

*Acidum Benzoicum*: 3 standard.

*Acidum Hydrobromicum*: 2 standard.

*Acidum Tannicum*: 15 standard; 1 inferior, containing a resin insoluble in water.

*Æther*: 6 standard; 2 inferior, containing too much alcohol.

*Æther fortior*: 3 standard.

*Alcohol*: 15 standard.

*Aqua Ammoniæ*: 5 standard; 2 inferior, containing too much water.

*Aqua Ammoniæ fortior*: 5 standard.

*Aqua Destillata*: 1 standard.

*Bismuthi Subnitras*: 2 standard.

*Cerii Oxulas*: 2 standard.

*Chloroform*: 3 standard.

*Extractum Glycyrrhizæ*: 1 standard; 2 inferior, containing considerable amounts of corn and wheat starch.

*Extractum Malti*: 1 of good quality.

*Ferri et Quinina Citras*: 7 not of the Pharmacopœal standard.

*Glycerinum*: 16 standard; 3 inferior, containing oils reducing nitrate of silver, one sample containing petroleum.

*Iodoform*: 1 standard.

*Lycopodium*: 2 standard.

*Liquor Magnesii Citratis*: 2 standard.

*Magnesii sulphas*: 1 standard.

*Oleum Olivæ*: 9 of good quality; 2 cotton-seed oils.

*Opii Pulvis*: 10 standard, 2 inferior, containing too little mor-  
ie.

*Potassii Acetas*: 5 standard; 3 inferior, containing considerable carbonate and chloride.

*Potassii Citras*: 6 standard.

*Potassii Iodidum*: 6 standard; 1 inferior, containing a considerable amount of chloride.

*Potassii Permanganas*: 6 standard.

*Pulvis Effervescens Compositus*: 13 standard in quality, but of considerable variety of weight, and the blue and white papers transposed in two instances.

*Pulvis Glycyrrhizæ Compositus*: 1 of inferior quality.

*Pulvis Rhei*: 9 standard.

*Quininæ Bisulphas*: 1 standard.

*Quininæ Sulphas*: 7 standard.

*Spiritus Frumenti*: 2 standard; 1 inferior, containing too much solid matter, chiefly sugar. The percentage of alcohol varied from 41 to 53.

*Spiritus Juniperi*: 2 of good quality and 2 inferior, being largely diluted with water.

*Spiritus Limonis*: 1 standard.

*Spiritus Vini Gallici*: 2 standard.

*Sulphur Lotum*: 12 standard; 1 inferior, containing 50 per cent. of gypsum.

*Syrupus*: 1 standard; 1 inferior, containing too much water.

*Tinctura Aconiti*: 6 standard.

*Tinctura Iodi*: 3 standard; 10 inferior, containing too little iodine, the deficiency being from 5 to 30 per cent.

*Tinctura Nucis Vomicae*: 4 standard; 5 inferior. This tincture should contain 2 per cent. of the dry extract. The samples submitted contained from 2.19 per cent. to 0.6 per cent.

*Tinctura Opii*: 25 standard; 27 inferior. This tincture should contain 1.3 to 1.5 per cent. of morphine by the Pharmacopœal assay. The samples submitted contained from 2.19 per cent. to 0.66 per



cent., the strongest tincture being more than three times as strong as the weakest.

*Vinum Album*: 4 samples not of Pharmacopœal quality, containing too much solid residue, chiefly sugar. The alcohol also was found to be from 1 to 3 per cent. in excess.

*Vinum Rubrum*: 16 samples not of Pharmacopœal quality. Here again there proved to be a large excess of sugar, while the alcohol varied from 2 per cent. below to 3 per cent. above the standard.

*Zingiber*: 1 standard.

*Miscellaneous*: 12 of good quality; 1 not of good quality. In this class were included samples of non-poisonous insect fluids composed of benzine, alcohol, peppermint, pennyroyal and borax.

A "wild cherry beverage" contained no hydrocyanic acid.

A sample of patent obesity pills contained nothing to be detected but sugar.

A sample of "freckle lotion" contained forty grains of corrosive sublimate per bottle.

Other face washes selling at one or two dollars per bottle were found to contain alcohol and citric acid in solution, and sulphur, chalk and gypsum in suspension.

A sample of "Black Pepsin" was found to consist of ground annatto and salt. It gave a slight pepsin digestion reaction.

A sample of "Compound Extract of Salix," prepared for preserving eggs, fruit and vegetables, proved to be salicylic acid.

#### SUMMARY.

|                           | Genuine. | Adulterated. | Total. |
|---------------------------|----------|--------------|--------|
| Milks, . . . . .          | 1,545    | 1,528        | 3,073  |
| Foods not milk, . . . . . | 2,763    | 377          | 3,140  |
| Drugs, . . . . .          | 228      | 99           | 327    |
| Totals, . . . . .         | 4,536    | 2,004        | 6,540  |

Respectfully submitted,

CHARLES P. WORCESTER.

## PROFESSOR GOESSMANN'S REPORT.

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The following report comprises the results of the analyses of samples of milk obtained in the four western counties of Massachusetts during the year ending Sept. 30, 1893.

The whole number examined was 187, of which 38, or 20.3 per cent., were below the standard. This result was but slightly greater than that of 1892 for the same district, which was 19.8 per cent.

The results of analyses were as follows : —

|                            |           |      |
|----------------------------|-----------|------|
| Whole number examined,     | . . . . . | 187  |
| Number above standard, .   | . . . . . | 149  |
| Number below standard, .   | . . . . . | 38   |
| Percentage below standard, | . . . . . | 20.3 |
| Samples of skimmed milk,   | . . . . . | 7    |

The statistics of the cities are as follows : —

### CHICOPEE.

|                            |           |      |
|----------------------------|-----------|------|
| Number of samples, .       | . . . . . | 16   |
| Number above standard, .   | . . . . . | 14   |
| Number below standard, .   | . . . . . | 2    |
| Percentage below standard, | . . . . . | 12.5 |
| Skimmed milk, .            | . . . . . | 2    |

### HOLYOKE.

|                            |           |    |
|----------------------------|-----------|----|
| Number of samples, .       | . . . . . | 16 |
| Number above standard, .   | . . . . . | 16 |
| Number below standard, .   | . . . . . | 0  |
| Percentage below standard, | . . . . . | 0  |
| Skimmed milk, .            | . . . . . | 2  |

### PITTSFIELD.

|                            |           |      |
|----------------------------|-----------|------|
| Number of samples, .       | . . . . . | 15   |
| Number above standard, .   | . . . . . | 9    |
| Number below standard, .   | . . . . . | 6    |
| Percentage below standard, | . . . . . | 40.0 |
| Skimmed milk, .            | . . . . . | 0    |

## SPRINGFIELD.

|                                      |      |
|--------------------------------------|------|
| Number of samples, . . . . .         | 37   |
| Number above standard, . . . . .     | 28   |
| Number below standard, . . . . .     | 9    |
| Percentage below standard, . . . . . | 24.3 |
| Skimmed milk, . . . . .              | 0    |

The results in the towns were as follows : —

|                        | Total. | Above<br>Standard. | Below<br>Standard. | Percentage<br>below<br>Standard. |
|------------------------|--------|--------------------|--------------------|----------------------------------|
| Adams, . . . . .       | 13     | 12                 | 1                  | —                                |
| Greenfield, . . . . .  | 12     | 10                 | 2                  | —                                |
| Lee, . . . . .         | 8      | 5                  | 3                  | —                                |
| North Adams, . . . . . | 42     | 34                 | 8                  | —                                |
| Orange, . . . . .      | 12     | 7                  | 5                  | —                                |
| Ware, . . . . .        | 16     | 14                 | 2                  | —                                |
|                        | 103    | 82                 | 21                 | 20.4                             |

AMHERST, MASS.

C. A. GOESSMANN,  
*Chemist.*

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## ISOLATION HOSPITALS FOR INFECTIOUS DISEASES.

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# ISOLATION HOSPITALS FOR INFECTIOUS DISEASES.

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By S. W. ABBOTT, M.D., Secretary of the Board.

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An increased demand, during the past two years, from the authorities of cities and large towns, and especially from manufacturing towns, for information on the subject of infectious disease hospitals has formed the incentive to the compilation of the following paper.

The essential difference between hospitals established for receiving patients attacked with infectious disease and other hospitals consists in the fact that the latter, the general hospitals, are maintained mainly for the purpose of affording care and treatment for the individual, while the former, the infectious disease hospitals, in affording this care and treatment also provide for the protection of the community at large, and thus constitute one of the essential measures for preventing the spread of infectious diseases by furnishing the means for isolating the first cases which appear in any community.

The principal reasons for providing these establishments in large cities are the following : —

*First.* Isolation constitutes the first and essential principle in the preventive treatment of the majority of infectious diseases. The more perfect the barrier between the sick and the well the greater becomes the certainty of staying the spread of infectious disease. On the other hand, the increasing accumulation of our population in the cities has a tendency to favor the spread of such disease. The urban population of Massachusetts (*i. e.*, people living in cities having more than 8,000 inhabitants in each), was only 27.1 per cent. of the total population of the State in 1840. In 1880 it had increased to 58.4 per cent., and in 1890 to 69.9 per cent. The urban population of the United States had also increased from 22.6 per cent. in 1880 to 29.1 per cent. in 1890.

To illustrate the effect which this crowding together of the population has upon the mortality from infectious diseases the following data are presented. They are the result of observations upon this subject extending over a period of twenty years in Massachusetts.

and were published in the twenty-third annual report of the State Board of Health, page 783, etc. They are here more conveniently grouped together in one table.

*Mortality from Eight Principal Infectious and Destructive Diseases in Dense, Medium and Sparsely Settled Districts in Massachusetts, that of Dense Districts being taken as 1,000.*

|               | MORTALITY FROM |          |                |                       |            |                   |              |            |                |
|---------------|----------------|----------|----------------|-----------------------|------------|-------------------|--------------|------------|----------------|
|               | All Causes.    | Measles. | Scarlet Fever. | Diphtheria and Croup. | Small-pox. | Cholera Infantum. | Consumption. | Pneumonia. | Typhoid Fever. |
| Dense, . . .  | 1,000          | 1,000    | 1,000          | 1,000                 | 1,000      | 1,000             | 1,000        | 1,000      | 1,000          |
| Medium, . . . | 826            | 617      | 818            | 780                   | 332        | 898               | 810          | 792        | 1,100          |
| Sparse, . . . | 760            | 445      | 587            | 634                   | 149        | 639               | 727          | 783        | 1,175          |

In using these terms, *dense* refers to those districts in which there was less than one acre to each inhabitant; *medium*, to those districts in which there was more than one acre but less than four acres to each inhabitant; and *sparse*, to those districts in which there were more than four acres to each inhabitant. By this table it appears that overcrowding has an unfavorable effect upon the mortality of each one of the foregoing diseases except typhoid fever.

*Secondly.* The inability of the majority of laborers and mechanics to furnish separate accommodations for the isolation of members of their families who may become ill with infectious disease is well known. Such families usually live in tenements having from one to four rooms, none of which can safely be devoted to the treatment and isolation of infectious diseases of a dangerous character. The serious overcrowding which prevails in some of the large cities of Great Britain has not yet been reached in any of our large cities, but the tendency is in that direction (Glasgow has a population of more than 100,000 living in one-room tenements). The very great increase of the population of this class by immigration has been the chief factor in causing overcrowding in our cities during the past decade.

*Third.* Another important advantage secured by the isolating hospital is found in the fact that the ordinary duties of the household, the attendance at school, and especially the support of the family by its wage-earners, can be carried on without disturbance, the danger of infection having been removed by the transfer of the sick member of the family to the hospital. It has not unfrequently happened that the local sanitary authorities in some of our cities and

towns have not only rigorously enforced the law relating to non-attendance at school, but have also quarantined the whole family, old and young; so that, by this means, the scholar is deprived of from two to ten weeks, or even more, of his educational privileges at the most important or most receptive period of his life, the length of time depending upon the duration of illness in the infected household; and more than this, the father and other wage-earners have been kept from work in the mill, the factory or the workshop. Even if he is allowed to work, his fellow workmen are wont to regard him with suspicion so long as a case of any one of the infectious fevers exists in his household. Now, the prompt removal of such cases permits the school attendance and the employment of other members of the family to go on undisturbed.

In all my experience with local boards of health during the past few years, I know of no circumstance or condition which has given more serious trouble and perplexity than this, nor do I know of any which is likely to be relieved to so great an extent as is this condition by the introduction of the isolating hospital.

So far as one disease (small-pox) is concerned, the principle of isolation in a hospital specially provided or designed for such purpose has been recognized from a very early period of our history. In 1701 an act was passed by the General Court "for the better preventing the spread of infection," wherein it was provided that "when persons were visited with the plague, small-pox or pestilential or malignant fever, and other contagious sickness, the infection whereof may be communicated to others," the selectmen were empowered to remove such infected persons to separate houses, and to provide "nurses, tendance and other assistance and necessaries for them, at the charge of the parties themselves, their parents or masters (if able), or otherwise at the charge of the town or place where they belong."

Small-pox has been shorn of much of its terrors by the discovery and practice of vaccination, so that while in the last century it furnished a very large percentage of the deaths the ratio of such mortality in the present century has been very greatly diminished.

The number of deaths from small-pox in the twenty years (1871-1890) in Massachusetts was 2,298, while those from measles, scarlet fever, diphtheria, croup and typhoid fever were, respectively, 3,984, 14,639, 36,553 and 19,421. If the ratio of cases to deaths maintained the average which has usually been observed, the total number of cases of these diseases which occurred in the State during



these twenty years must have been at least 700,000. Had adequate provision been furnished for controlling epidemics at their outset, it is safe to say that a very considerable portion of these lives, and also of these cases of illness, might have been saved. The provision of isolating hospitals constitutes one important measure for controlling such epidemics, while prompt notification by the attending physicians, disinfection, vaccination and restriction of school attendance from infected families also constitute a part of the same general plan of action.

Hospitals for infectious diseases have reached their highest type of development in England, but are not yet in very common use in the continental countries of Europe. In commenting upon the history of this subject, Dr. Buchanan says, in his introduction to the special report to the Local Government Board of England upon the "Use and Influence of Hospitals for Infectious Diseases":—

The original design of these hospitals in England was to promote the recovery of the individual poor patient for whom other accommodation was wanting; indeed, the name "house of recovery" was a frequent synonym for infectious disease hospital at the period when such an institution was first seen to be necessary. But it was inevitable that the advantages to be obtained by the district possessing a hospital should soon force themselves upon the attention of the observer, and from a very early period of their history infectious disease hospitals have been advocated on the ground of their protecting the household against the spread of infection.

The benefits of these hospitals were not, however, obtained without a good deal of misfortune within the walls of the institutions themselves. In the small-pox hospital, indeed, this was not apparent. Small-pox had been regarded from the beginning as requiring a special building for itself. It had a "specific" contagion, which could not be safely treated under the same roof with the "general" contagion of fever. So, in the hospital where no disease but small-pox was received, patients had no opportunity of contracting other diseases. The nurses, in early times selected from among those who had passed through an attack of small-pox, and in later times, having their vaccination specially cared for, took nothing from their patients; but in the "fever hospital" the case was different. Doctors and nurses caught fever, in some years more than in others, while convalescent patients had what appeared to be repetitions of fever attacks. So serious indeed did these misadventures become that forty years ago it had come to be spoken of as doubtful whether fever cases, if they were to be treated in hospitals at all, had not better be distributed through the wards of general hospitals. The experiment was tried, but with far greater disaster to the patients and attendants of the general hospital.

In the foregoing quotation the special form of fever to which reference is made is undoubtedly typhus, and not typhoid or enteric fever.

With reference to the propriety of separating isolating hospitals absolutely from all other establishments, Dr. Rowe says in his recent paper upon this subject: —

In large communities the only system that is beyond criticism is to make for infectious diseases a separate establishment, independent and isolated. . . . It is the duty of hospital workers and sanitarians not to cease forcing upon public authorities the necessity of intelligent action, until every municipality, through its public treasury, shall provide special hospitals always available for infectious diseases. Is it not the wisest policy to put such hospitals under the immediate control of the local board of health? They have so close a connection with other vital matters properly belonging to health boards that it conduces to unity of action to have the suppression of infection under one authority, a practice that obtains in Great Britain.\*

As early as 1866 an act of Parliament had given to local authorities the power to erect and to maintain hospitals for isolation of persons suffering with contagious diseases. This power was further enlarged by the general Public Health Act of 1875. As a result of this legislation it was found by returns made in 1879 that 296 authorities had availed themselves of this privilege in the erection of buildings of one sort or another for this specific purpose. The arrangements were in some cases rudimentary and insufficient, and on the other hand some authorities had wisely and liberally used their powers in providing efficient hospitals for the reception of persons suffering with contagious fevers and from small-pox.

In a brief paper upon the same subject presented at the International Congress of Hygiene at London in 1891, Dr. Thorne states that this number had increased to 400, and that the general adoption of the provisions of the Infectious Disease (Notification) Act of 1889 was likely to lead to a still further increase in the number of these establishments.

In commenting upon the diseases calling for isolation, Dr. Thorne says: —

So far, there is no evidence that aggregation of the infectious sick suffering from any of these diseases, except small-pox, such as is likely to be carried out by any ordinary sanitary authority, leads to infection of the

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\* Paper read at Congress of Charities, Correction and Philanthropy, at Chicago, June, 1893.

surrounding community, provided that the hospital be properly constructed and administered, and subject to a zone of some forty feet being provided between all buildings intended to receive infected persons or things and the boundary wall, or close fence around the site. Experience has shown that it is otherwise with small-pox, and it yet remains to be ascertained what are the circumstances under which cases of that disease can be aggregated for the purposes of sanitary authorities without risk to the community. Fortunately, owing to the protection afforded by vaccination, small-pox does not, as is commonly supposed, stand foremost among the infectious fevers calling for isolation in a hospital. As a rule, port sanitary authorities alone make provision for cholera.

*Extent of Provision.* — No exact rule can be laid down as to the requisite amount of provision for any given population. A general estimate has been made in England of one bed to each 1,000 inhabitants as sufficient for ordinary requirements. But the character of the population must largely determine this question. Upon this point Dr. Thorne says: —

In a locality where the population is well-to-do, and most houses are of a size and construction that offer reasonable facilities for the isolation of single attacks of the current infectious fevers, the amount of hospital accommodation needed for public health purposes will be less than in a manufacturing district, where disease cannot be treated in the houses in which it breaks out without very great if not certain risk of spread.

With this point in view, it is quite plain that the amount of hospital provision per 1,000 inhabitants in a residential community like those of Brookline or Newton would necessarily be less than it would be in manufacturing cities like Lowell, Lawrence, Fall River and Worcester.

*Character of Accommodation Required.* — Dr. Thorne has so distinctly presented the essential conditions relative to the necessary accommodations of an infectious disease hospital in his recent paper at the International Congress of Hygiene, that I take the liberty to quote them as applicable in most particulars to our own cities: —

Premising that all the conditions that are deemed essential in the provision of a healthy dwelling-house are to be regarded as equally desirable in the case of an infectious hospital, I would only here refer to such other points as involve considerations peculiar to such hospitals.

(a) *As regards site.* — It is, as a rule, undesirable to select any site which is less than some two acres in extent; and, even then, regard should

be had to the need for extension of hospital buildings, whether for temporary purposes or owing to increase of population. Where practicable, only single-story hospital pavilions should be contemplated; and having regard to their distribution on the site, and to the outdoor exercise of convalescents, twenty patients to the acre will generally be found to be the limit of aggregation of sick on area.

(b) *As regards buildings.* — The administrative building should be distinct from all others. Nurses, when off duty, will live and sleep in it; tradesmen will call there for orders and with supplies, and relatives will there make inquiries as to the progress of the sick. This building should always be so placed as to control all access from without to the ward pavilions and other hospital buildings. The laundry, ambulance shed, disinfecting apparatus and mortuary should also be in one or more buildings separate from the administrative building and the ward pavilions.

No sanitary district can be regarded as properly provided for unless it has immediately available sufficient accommodation for the isolation of two different infectious diseases in both sexes, and some means for the special isolation of one or two patients needing separate accommodation, as, for example, cases in which the nature of the disease is at first doubtful. These requirements are usually met by the provision of two pairs of wards or rooms having no aerial communication with each other, together with one or two special isolation rooms. In sparsely populated districts these requirements may be combined in one pavilion, the separate apartments of which open separately upon verandahs. Such a building is commonly styled an isolated pavilion.

Each ward pavilion should admit of cross ventilation by means of windows in the two opposite side walls; the closets and ward sinks, having themselves independent means of cross ventilation, should be entered from the wards by means of a cross-ventilated lobby; all angles, vertical and horizontal, should be rounded, to prevent deposit of dust, etc., and a nurse's duty room should be provided. Assuming that each ward will contain the ordinary proportion of acute and convalescent patients, and that it is adequately ventilated and warmed, a minimum of 2,000 cubic feet of air per head is generally found to suffice in order to maintain reasonable purity of air; but much depends on the allotment of this amount of air to the individual patient. No excess in the amount of total air provided — as, for example, in the case of lofty wards — can compensate for crowding patients on the floor level; and hence the beds should be so arranged as to ensure for each patient a floor-space of some 156 square feet. And since it is in the neighborhood of the patient's mouth and nostrils that it is above all important to maintain the purity of ward air, it is of all things necessary to allot to each bed a separate amount of wall space, not less than some twelve feet in length.

(c) *As to allotment of bed-space.* — The best position for the beds is that one bed should occupy each one wall-space between a pair of win-

dows, the head of the bed to be at least one foot away from the wall, so as to facilitate movement of air about the patient's head.

Medical advice is often sought as to the number of beds that should be placed in any one ward of an infectious hospital. In suggesting an answer to this question I cannot avoid the conclusion that the practice of treating sick persons under circumstances which admit of the air by which they are surrounded being charged more or less by the emanations of other sick persons is wrong in principle, and that from this point of view any aggregation of the sick in wards is undesirable. But other considerations must, in the case of a large proportion of the population, be regarded as outweighing this one; and all that can be properly contended for is that the limit of such aggregation shall be decided by considerations such as are involved in securing freedom from any recognizable risk, together with such efficiency in general administration and nursing as is consistent with a reasonable regard for economy.

The several infectious fevers doubtless differ in regard to the amount of nursing which the sick require; but taking them as a group, and assuming that the ordinary proportion of acute and convalescing cases at varying ages are brought together, it may be held that any one nurse can rarely be expected to take charge of more than twelve patients. The moment this number is exceeded the nursing staff has to be doubled, and directly a second nurse is required it would be better in the interests of the sick that those whom she nurses should be in a separate ward. Holding this in view, I believe it will generally be found desirable that infectious hospitals should be built in pavilions so contrived that in each there shall be two wards, one for males and the other for females, containing together not more than twelve beds, the two six-bedded wards to be separated by nurses' duty-room and an entrance lobby.

*The diseases for which persons may properly be treated in infectious disease hospitals* are mainly those which are specially contagious in their nature, and are liable to spread from the sick to the well in consequence of proximity to each other in the small and ill-ventilated tenements of large cities. It frequently happens also that travellers stopping at hotels or boarding-houses are attacked with some infectious disease, and the business of the establishment is seriously hindered and sometimes stopped altogether for a time by the presence even of a single case of such disease. I have had occasion several times in the past ten years to investigate instances in which these circumstances were prominent. Under ordinary rules such cases cannot be admitted to the general hospital, but may very properly be taken to an isolation hospital for treatment.

The diseases which should be treated in infectious disease hospitals are scarlet fever, diphtheria, small-pox, measles, typhus fever, cholera, typhoid fever, and to these it would be proper to add in the Southern States yellow fever, a disease from which the New England States are generally exempt.

Practically, the first five diseases mentioned in the foregoing list are those for which provision is usually made in isolation hospitals. In referring to English practice upon this point Dr. Thorne says :—

Next to small-pox, scarlet fever is the disease for the isolation of which most efforts have been made by sanitary authorities. The various forms of continued fever, and notably cases of enteric fever, have also in many districts been somewhat extensively isolated. Diphtheria and erysipelas have occasionally been dealt with in isolation hospitals, and at times efforts have been made to stay the spread of measles in the same way. There are, however, conditions which render attempts to deal with measles by means of isolation specially difficult. The stage at which the disease becomes infectious often precedes that in which it is recognized; the subjects of its attack are as a rule of exceptionally tender years, and a large proportion of cases never come under medical treatment at all. Notwithstanding its fatality, therefore, it can hardly be expected that hospital provision by sanitary authorities will be deemed as pressing in the case of measles as in some other infectious diseases.

Scarlet fever is the disease for which isolation is most constantly and most urgently needed. The mortality it occasions exceeds that of any other communicable fever prevalent in this country. It is highly infectious, and there are no effectual means apart from isolation by which its spread can be stayed. Small-pox, the one disease which, if vaccination were properly carried out, should least call for hospital provision, may perhaps be deemed to stand next in order as regards the measures for isolation. In some towns typhus has prior claims to small-pox in this respect, and in all districts some provision should be made for the other continued fevers.

The foregoing extract from Dr. Thorne's report applies with equal force to the case of our own cities and towns at the present time, with this exception, that we should give much greater prominence to diphtheria as a disease requiring hospital isolation. The very slight importance apparently attached to diphtheria in the English report of 1880 is undoubtedly accounted for by the fact that the contagious character of the disease was not then so thoroughly established as it is at the present time, a dozen years later. A peculiar characteristic of diphtheria appears to be the permanence of its infection, and the liability to retain its vitality in houses and apart-

ments for a considerable period of time. Hence the propriety of speedy removal of infected persons to a special hospital constructed with reference to efficient methods of disinfection, which are ill-adapted for use in old, crowded and ill-ventilated tenements, which, with walls and floors and ceilings having many cracks, crevices and crannies, give abundant opportunity to harbor the specific infectious material of diphtheria.

While the mode of transmission of the infection of typhoid fever differs essentially from that of some of the other infectious diseases already named, it is undoubtedly true that many cases occur by means of personal infection from one person to another, and while the alimentary tract is the part through which the specific poison is received, and often by means of the public or private water supply, the fact should not be overlooked that there may be other modes of transmission than through the medium of the water supply. While writing this paper I had occasion to investigate a local epidemic in a small town, having circumstances which may briefly be stated as follows: In January last, a man was attendant as a nurse and watcher upon a typhoid fever patient living about two miles distant from his own house. After the recovery of the patient he went home and was taken ill with typhoid fever himself, and after him, successively, three of his children, a grandchild, and finally his wife, the disease having in his household a continuous history of six months' duration. Careful examination was made of the surroundings of the house, the water supply, the disposal of refuse, etc., and it did not appear that the local conditions were at fault, but the probability lay in the direction of personal infection from the first case to the second, and so on through the family. Doubtless food and possibly milk may have been a means of transmission of infection; but if the first case could have been taken to a hospital and isolated during his illness and convalescence, it is probable that all the remaining members of the family would have escaped the disease.

This is only a single example of multitudes of such cases, which are constantly recurring and in which a system of well planned isolating hospitals would necessarily diminish very greatly the number of cases of illness as well as the mortality. The practical result of such a plan when properly administered, is to limit outbreaks of infectious disease to the first cases and thus to prevent the occurrence of epidemics.

*Further points relative to construction.*—Brick, stone or iron are undoubtedly better than wood, and this statement applies more decidedly to infectious disease hospitals than to those which are to be used for general purposes. Especially is this true of the interior finish of wards and other apartments used by the sick. It is advisable to finish the walls and ceilings with a hard or impermeable surface, which has no cracks or inaccessible ledges which may retain infection, and a floor of best asphalt or of some similar impermeable material, although possessing slight disadvantages, is so much superior to wood for the purpose of cleaning, as to be well worthy of adoption for such uses in wards which are to be devoted to the most infectious diseases.

In adapting dwelling houses in small districts to the uses of infectious disease hospitals special care should be taken to select houses in isolated positions. Such buildings should not be used for this purpose in large cities.

Such hospitals should be erected in a careful and considerate manner, with due regard to growth of population, and upon a well defined plan. Dr. Thorne's inquiry showed that—

The suitability of the hospital buildings in various parts of the country was to a very great extent dependent upon the circumstances under which they were erected. If a hospital is hurriedly built under the influence of panic, it is often not ready for occupation until the immediate cause of its erection has passed by; it provides accommodation of a very indifferent sort; it fails, almost without exception, to meet the permanent requirements of the district even when in amount it turns out to be more than the district needs; and thus the object of the hospital as a part of the sanitary defences of the district is often attained in a very imperfect manner and at a needlessly large cost.

*Possibility of spreading infection.*—It has sometimes been urged that such hospitals might become centres of infection from which diseases would spread to the neighboring districts. Careful investigation upon this point, however, among the numerous hospitals of this sort in Great Britain showed that no danger need be feared from this source except in the case of small-pox. A thorough investigation made by Dr. Power, in 1882, and reported to the Local Government Board, showed that in the neighborhood of the Fulham small-pox hospital in London, small-pox had increased almost in a direct ratio to the nearness of the population to the hospital. This



increase was also independent of lines of human intercourse. In point of time there was also a very marked relation between the varying use of the hospital and the manifestations of excessive small-pox in the neighborhood.

Hence much greater care is necessary in selecting an isolated site in the case of hospitals intended for the reception of small-pox patients than is necessary in the case of those which are to be used for other infectious diseases.

The following condensed table and general conclusions are taken from Dr. Power's report :—

*Admissions of Acute Small-pox to Fulham Hospital, and Incidence of Small-pox upon Houses in Several Divisions of the Special Area during Five Epidemic Periods.*

| CASES OF<br>ACUTE SMALL-<br>POX ADMITTED. | In Epidemic Periods<br>Since Opening of<br>Hospital. | INCIDENCE ON EVERY HUNDRED HOUSES WITHIN THE SPECIAL<br>AREA AND ITS DIVISIONS. |                                              |                                                         |                                                          |                                            |
|-------------------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------|----------------------------------------------|---------------------------------------------------------|----------------------------------------------------------|--------------------------------------------|
|                                           |                                                      | On Total<br>Special<br>Area.                                                    | On Small<br>Circle 0- $\frac{1}{4}$<br>Mile. | On First<br>Ring $\frac{1}{4}$ - $\frac{1}{2}$<br>Mile. | On Second<br>Ring $\frac{1}{2}$ - $\frac{3}{4}$<br>Mile. | On Third<br>Ring $\frac{3}{4}$ -1<br>Mile. |
| 327, . .                                  | Mar., 1877-end of 1877,                              | 1.10                                                                            | 3.47                                         | 1.37                                                    | 1.27                                                     | .36                                        |
| 714, . .                                  | Jan., 1878-Sept., 1878,                              | 1.80                                                                            | 4.62                                         | 2.55                                                    | 1.84                                                     | .67                                        |
| 679, . .                                  | Sept., 1878-Oct., 1879,                              | 1.68                                                                            | 4.40                                         | 2.63                                                    | 1.49                                                     | .64                                        |
| 292, . .                                  | Oct., 1879-Dec., 1880,                               | .58                                                                             | 1.85                                         | 1.06                                                    | .30                                                      | .23                                        |
| 515, . .                                  | Dec., 1880-Apr., 1881,                               | 1.21                                                                            | 3.00                                         | 1.54                                                    | 1.25                                                     | .61                                        |
| 2,527, . .                                | Five periods, . . .                                  | 6.37                                                                            | 17.35                                        | 9.20                                                    | 6.16                                                     | 2.57                                       |

#### CONCLUSIONS RELATIVE TO THE SPREAD OF SMALL-POX IN THE NEIGHBORHOOD OF HOSPITALS.

1. There has been in each epidemic period an excessive incidence of small-pox in houses in the neighborhood of the hospital as compared with more distant houses in Chelsea, Fulham and Kensington.

2. The percentage of houses invaded in the neighborhood of the hospital has become gradually smaller as the distance of the houses from the hospital has increased.

This gradation has been very exact and very constant.

3. Houses upon the chief lines of human intercourse with the hospital have not suffered more than houses lying in other directions from the hospital.

4. In point of time, there has been a very marked relation between the varying use of the hospital and the manifestations of excessive small-pox in the neighborhood.

This relation has not shown itself while the use of the hospital has been for convalescents only.

5. The appearance of excessive small-pox in houses around the hospital has never been delayed until the hospital has become full, or nearly full. It has been always most remarkable at the time when admissions to the hospital were beginning to increase rapidly.

In the succeeding months of active operations, though the use of the hospital may have gone on increasing, the excess of small-pox upon the neighborhood has habitually become less marked.

6. On comparison of different epidemics an almost constant ratio is observed between the amount of the hospital operations and the degree of excess of small-pox in the neighborhood.

7. The machinery of the hospital administration, with inclusion of defects in that machinery, does not account for the peculiarity of small-pox incidence within the three parishes of Chelsea, Fulham and Kensington since the establishment of the hospital.

8. There must have been some condition or conditions operating to produce the observed distribution of small-pox around the hospital that have pertained to the hospital as such, and that have been in excess of the condition of small-pox extension as usually recognized.

9. During the present epidemic period, and most probably during former similar periods, there has arisen in the atmospheric circumstances of the time, peculiar facility for the dissemination in an undamaged state of any matter that may have been given off from the hospital.

*Disinfecting Apparatus.* — An isolating hospital can hardly be said to be complete in all its appliances without a well-equipped disinfecting apparatus. This may be used, not only for the purpose of disinfecting the infected material which must necessarily be found in every such hospital, but will also prove a powerful ally to the local board of health for the disinfection of the infected articles which are to be found wherever scarlet fever, diphtheria, typhoid fever and other infectious diseases exist. Such articles include clothing, bed linen, mattresses, and all the textile fabrics which are capable of disinfection and are too valuable to be destroyed. Such disinfecting stations exist in Berlin and in Paris as separate establishments, and are conducted in the most thorough manner, and in accordance with the most approved methods. There is no reason, however, why they may not be employed as adjuncts to isolating hospitals, where such hospitals exist. The Board of Health of Boston has during the past year established such a station at its new infectious hospital at Swett Street.

Efficient forms of disinfecting apparatus are also made for use in a portable shape, and are now made, both in this country and in Europe, at considerably less cost than the stationary establishments.

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Let us for a moment consider a practical illustration of such a system as I have outlined: A father, mother and four small children, the latter aged two, four, six and nine years, occupy a tenement of two rooms, including a kitchen and sleeping room, each about twelve feet square and seven and a half or eight feet high. The kitchen is the cooking and living room of the family, and both are heated by the kitchen stove. The sleeping room is occupied at night by the whole family, and after allowing for the space taken by the furniture there are in this room about 175 cubic feet of air space only to each person, which is doubled by the open door into the kitchen. The sleeping room has but one window, which, in winter, is kept constantly closed, and there is no special means for ventilation. I am not here describing an unusual case, but, on the contrary, one which is of very common occurrence in any one of our large manufacturing cities.

One of these little children is taken ill with diphtheria in its severest form. There is no provision in the city for such cases, and the mother gives the child the best care which she can afford under the circumstances. The neighbors are afraid to take the other children to their homes. The next child is too young to attend school, and the law excludes the older children from school during the prevalence of illness in the family, thus making their exposure to infection more certain. After days of weary watching another child falls ill, and then perhaps the mother herself, worn with care and solicitude for her little ones, becomes a victim to the disease. Meanwhile the youngest has died, and is laid out for burial in a corner of the kitchen, the living room of the family.

Dr. Russell, the health officer of Glasgow, in commenting upon such cases, which, in a crowded city like Glasgow, were once of very frequent occurrence, says, when contrasting the condition of the rich and of the poor: —

Last of all, when *you* die, *you* still have one room to yourself, where in decency you may be washed and dressed and laid out for burial. If *that one room* were your house, what a ghastly intrusion you would be. The

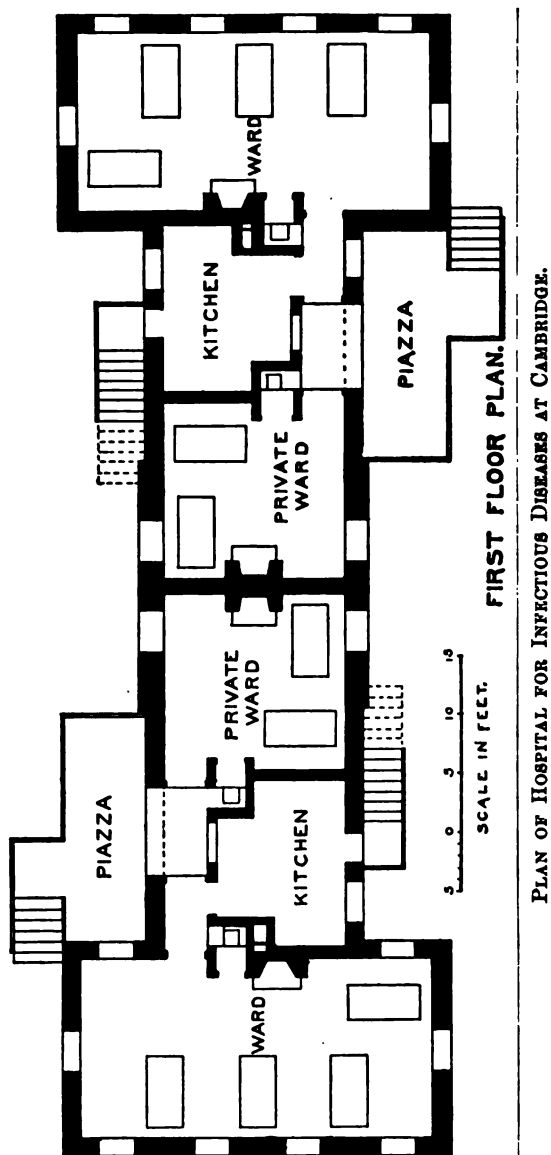
bed on which you lie is wanted for the accommodation of the living. The table at which your children ought to sit must bear your coffin, and they must keep your unwelcome company. Day and night you lie there until with difficulty those who carry you out thread their tortuous way along the dark lobby and down the narrow stair through a crowd of women and children. You are driven along the busy and unsympathetic streets, lumbering beneath the vehicle which conveys your scanty company to the distant and cheerless cemetery, where the acrid and deadly air of the city in which you lived will still blow over you and prevent even a blade of grass from growing over your grave.

Dr. Russell has here graphically described a death among the abodes of the poor, but when the death is from infectious disease, the conditions are still worse, since the added danger of infection to the remaining members of the family only doubles the distress of the household. Now for such conditions as I have described the infectious disease hospital provides a most excellent remedy, and while it may not prevent the occurrence of the first case in the family, it does provide for the taking of the infected person to a suitable place where he will not only receive far better care himself, but will not transmit the infection to his brothers, his sisters or to any other person.

In the hospital, too, in place of overcrowded and ill-ventilated bed chambers, there are large and well-ventilated wards; in place of foul air and darkness, there is fresh air and sunlight; in place of scanty food and food that is ill adapted to the wants of the sick there is food selected especially for the case in hand, and more than all this, there is good nursing and the best of care, and when the patient has recovered he is returned to his family, no longer a source of danger and of infection.

Of the few establishments of this character now in use in this State, one is at the State Primary School at Monson, where it was built about ten years ago for the purpose of receiving any cases of infectious disease which might arise in the school. It has proved exceedingly useful for the purpose of isolating such cases of scarlet fever, diphtheria and measles as have occurred in the school, and has undoubtedly prevented the outbreak and continuance of severe epidemics of these diseases, which are very liable to occur among children of such ages as are usually received at this school. When no means are provided for isolating sick children such epidemics often make sad havoc among them.

This hospital contains four wards capable of accommodating about twenty to thirty patients. It is entirely separated from the other buildings.



PLAN OF HOSPITAL FOR INFECTIOUS DISEASES AT CAMBRIDGE.

Still more recently an isolating hospital, very well planned and conveniently arranged, has been built at Cambridge, under the supervision of the trustees of the Cambridge Hospital.

A general plan of the main floor of this building is shown upon page 706. The arrangement of wards in this building is so planned as to admit of the treatment of two diseases, and also of the two sexes in each case, without any possible communication between the two halves of the hospital. Fourteen beds can conveniently be accommodated in the building. There are also two rooms for nurses in a second story not shown in the plan, separate from each other, each room being reached by a separate stairway.

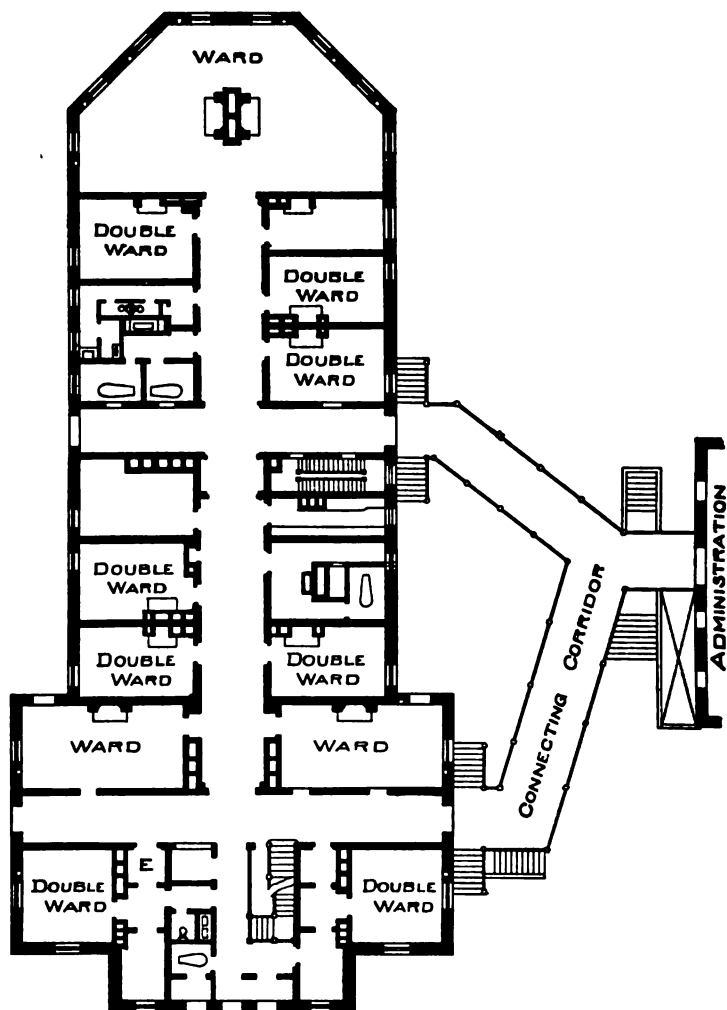
In describing the conditions essential to a well-contrived isolating hospital for a large city, Dr. Rowe makes the following valuable suggestions, some of which could hardly be carried out to the letter, except in large and wealthy communities :—

The wards should be of moderate size, not to exceed thirty beds. The number of buildings for each disease should be sufficient to allow one building to, so to speak, "lie fallow" for renovation and disinfection. This reserve is a large factor in reducing the mortality in an infectious disease hospital. This generous installation of site, buildings and appointments is not always practicable, either from the topography of a city, an available site or the financial condition of a municipality. Such establishments, however, do exist. The Belvidere Hospital for Infectious Diseases in Glasgow, Scotland, is a most notable example. It covers thirty-one acres of land, and has thirty-five buildings with accommodations for infection usually prevalent in a large city. No better argument for isolation hospitals can be adduced than a rehearsal of the experience of the health authorities of Glasgow, in changing the most unhealthy city of Great Britain, with the largest mortality rate, into a clean, healthful city, with a low death-rate.

Acting in conformity with the principles which Dr. Rowe has laid down in the paper from which I have here quoted, the trustees of the Boston City Hospital have now made provision for this purpose upon a lot of land near the city hospital in Boston. The group of seven buildings comprising this hospital, now nearly completed, consists of two two-story ward pavilions, connected by covered corridors with an administration building. The other buildings are a convenient lodge-house, a nurses' home, and a boiler-house, laundry, mortuary, etc. The cut on page 708 shows the first floor of one of the two ward-pavilions now approaching completion. As at present arranged, the wards are designed for 136 patients.

The wards at the City Hospital, now occupied for the reception of patients ill with diphtheria and scarlet-fever, were intended for only forty-two patients, but the urgent demands made upon the hospital

**SOUTH PAVILION  
OF  
BOSTON CITY HOSPITAL  
FOR  
CONTAGIOUS DISEASES.**



SCALE

for receiving this class of cases has required them to be occupied by sixty patients much of the time.

“These difficulties,” say the trustees in their report of the year 1892, “will soon be remedied by the completion of the Chester Park Hospital. For the purpose of carrying out this work \$271,000 were placed at the disposal of the trustees for the construction of new buildings, \$24,000 were set apart for the construction of a new ambulance stable, and contracts were made for the buildings, to cost \$203,000.”

In referring to this department of the work of the city hospital for the year 1892, Dr. Rowe says :—

The contagious service has been extremely active, a larger number of patients having been admitted than during any previous year. The total number of patients admitted with scarlet fever, diphtheria and other complications was 788. . . .

The diphtheria ward has seldom been crowded, although during several months it has been full. The character of the cases was severe, the marked characteristic being that a very large number were brought to the hospital in the last extremity. It follows that the mortality has been large. The scarlet fever ward has not only been full at all times, but during the winter months it has been crowded beyond a limit that was judicious. The hospital attempted to provide for all cases of scarlet fever that applied for relief. . . . Some applicants have been rejected because the wards were crowded to an extent detrimental to those under treatment. . . . When the new hospital for contagious diseases is completed it is expected its capacity will meet not only the present demands but also provide for any epidemics such as have hitherto existed in Boston, and also keep pace with the growth of the population.

The increasing favor with which hospital treatment for infectious diseases is regarded by the public is shown by the fact that in London the numbers admitted to the hospitals of the Metropolitan Asylum's Board increased from 2,197 in 1886 to 8,334 in 1890. One-third of all the infectious cases legally admissable were treated in those hospitals in 1890. In Brighton, England, in 1891, 70 per cent. of scarlet fever cases were so isolated.

“The whole drift of hospital provision is toward the prevention of epidemics by the isolation of first cases of infectious disease, the improvement of the treatment of the cases admitted upon that obtained at home being but part of the main object, but tending materially to diminish the mortality.”

A very good illustration of a small and well-designed isolation hospital for a residential town of 20,000 inhabitants, or for a manu-



facturing town of a smaller population, may be found in the hospital at Ealing, England, which is represented in the accompanying illustrations. The grounds cover about two acres in a convenient location upon the outskirts of the village. The plan includes a hospital for about twelve or sixteen beds, with wards for two diseases, and opportunity to separate the sexes.

An administration house, porters' lodge, laundry, mortuary, ambulance shed and disinfecting apparatus are also provided. The grounds are surrounded by a brick wall about six feet in height. Space is also shown where tents may be erected upon a concrete floor in case of an unusual epidemic. The same space may also be used for future hospital extensions.

The cost of this establishment was about \$30,000, including cost of land.

In the construction of buildings of this character the same general rules should be adopted as are applicable to hospitals in general. The trustees or committees appointed to take charge of construction should make themselves acquainted with everything requisite to secure the best buildings for hospital purposes which modern science and trained experience can produce. In illustration of the neglect of this precautionary measure Mr. H. C. Burdett, author of "*Hospitals and Asylums of the World*," cites the following instance : —

This very autumn we had to inspect a new hospital, costing many thousands of pounds, where the committee and medical staff had taken infinite pains to secure a type of buildings which should be so good as to make their institution an example for others to follow. We found, however, that the buildings actually erected were a failure, and, what is more, a failure of the worst kind ; that is to say, the faults were such as to astonish any one who had taken the trouble to make himself practically acquainted with modern progress in hospital construction. These faults were not due to the character of the site, or to any special circumstance, but arose entirely from ignorance, and what we venture to think is worse than ignorance, namely, an attempt on the part of the architect to adopt what he believed, no doubt, to be modern improvements without making himself acquainted with the purposes those improvements were intended to effect.

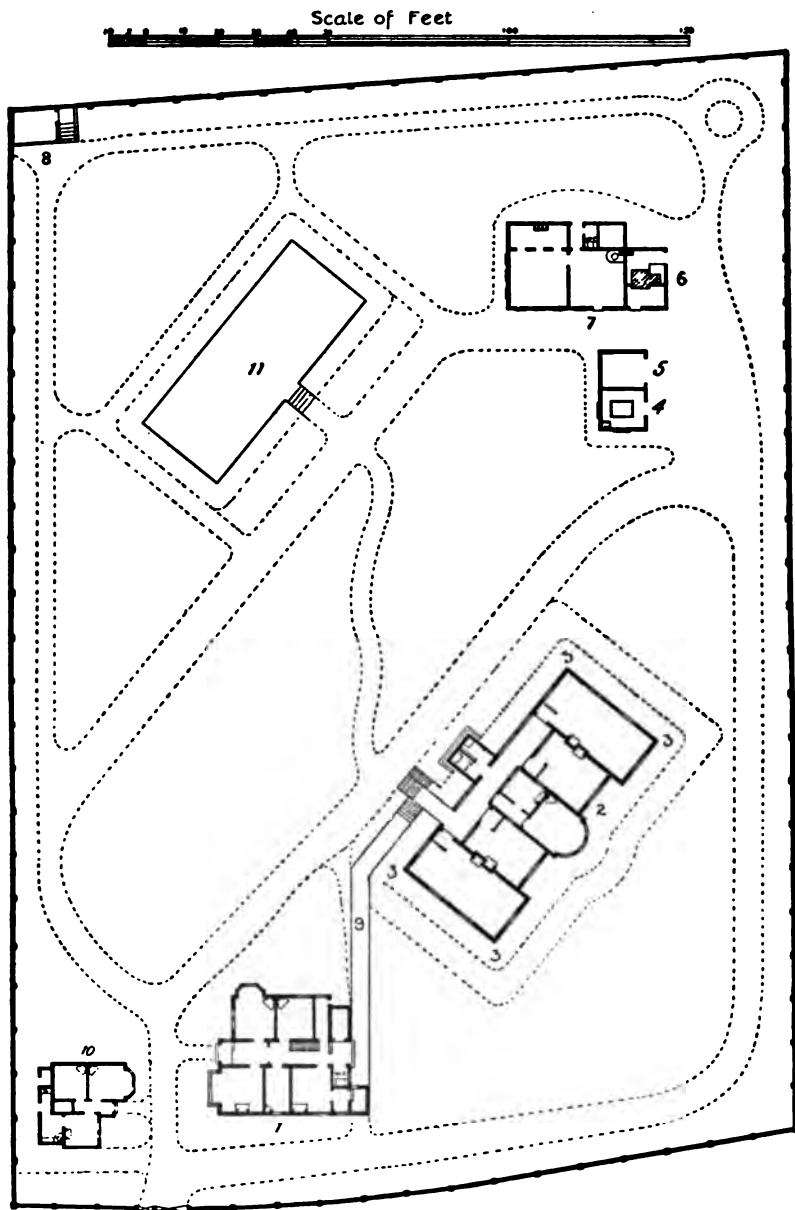
One of the first hospitals of this class was the London Fever Hospital, established about 1802, at Gray's Inn Road, and then known as a "house of recovery," where patients convalescing from *infectious diseases* could be taken while their homes were being cleansed or disinfected. It was afterward removed to better quarters, where





EALING ISOLATION HOSPITAL.

# EALING ISOLATION HOSPITAL



## EXPLANATION.

1. Administration Block. 2. Hospital Block. 3. Area under the same, 6 feet headway.  
 4. Mortuary. 5. Ambulance. 6. Disinfecting Chamber. 7. Laundry. 8. Conservatory.  
 9. Covered Corridor. 10. Porter's Lodge. 11. Concrete floor for tents.

it served the purpose of isolating the infected sick, and thus protecting the healthy part of the population. (See plan of present London Fever Hospital, page 713.) The rows of dwellings upon each side of this hospital show its close relation to the neighboring population.

Since the scope of this paper will not admit of the details of hospital construction the reader may be referred with advantage to the excellent work of Mr. H. C. Burdett recently published, entitled “Hospitals and Asylums of the World.”

In the fourth volume of this work are given brief descriptions of the following hospitals devoted to the care of persons suffering with infectious diseases : —

\*London Fever Hospital.

| Small-pox Hospital, Highgate (Lon.).

*Hospitals of the Metropolitan Asylum's Board.*

\*Eastern (Homerton).

| Western (Fulham).

South Western (Stockwell).

| North Eastern (Tottenham).

\*Northern (Winchmore Hill).

| Hospital Ships (Long Reach).

Northwestern (Hampstead).

| \*Ambulance Stations.

\*South Eastern (New Cross).

*Provincial Infectious Hospitals.*

Belvidere Hospital (Glasgow).

| Netherfield Institution for Infectious Diseases (Liverpool).

\*Bradford Fever Hospital.

Bolton Borough Hospital.

| \*New City Hospital (South), Grafton Street (Liverpool).

\*City Hospital for Infectious Diseases (Newcastle-upon-Tyne).

Delancey Hospital (Cheltenham).

| Nottingham Borough Epidemic Hospital.

Gateshead Hospital.

| Port Sanitary Authority's Hospital (London).

\*Heathcote Hospital (Leamington).

Hull Corporation Sanatorium.

| \*River Tyne Port Sanitary Authority's Hospital.

Infectious Hospital for the Joint Counties (Carmarthen).

Isolation Hospital (Huddersfield).

| Sanitary Hospital at Bournemouth.

Isolation Hospital (Oldham).

| Sheffield Borough Hospital for Infectious Diseases.

Isolation Hospital (Hornsey).

| Sittingbourne & Milton Joint Infectious Hospital.

Kendray Fever Hospital (Barnsley).

Ladywell Sanatorium (Salford).

| Temporary Small-pox Hospital (Liverpool).

Leeds House of Recovery.

Monsall Hospital at Manchester.

*Continental Infectious Hospitals.*

\*Blegdams Hospital (Copenhagen).

\*Ullevold's Hospital, Christiania Communal Epidemic Hospital (Sweden).

Oresunds Hospital.

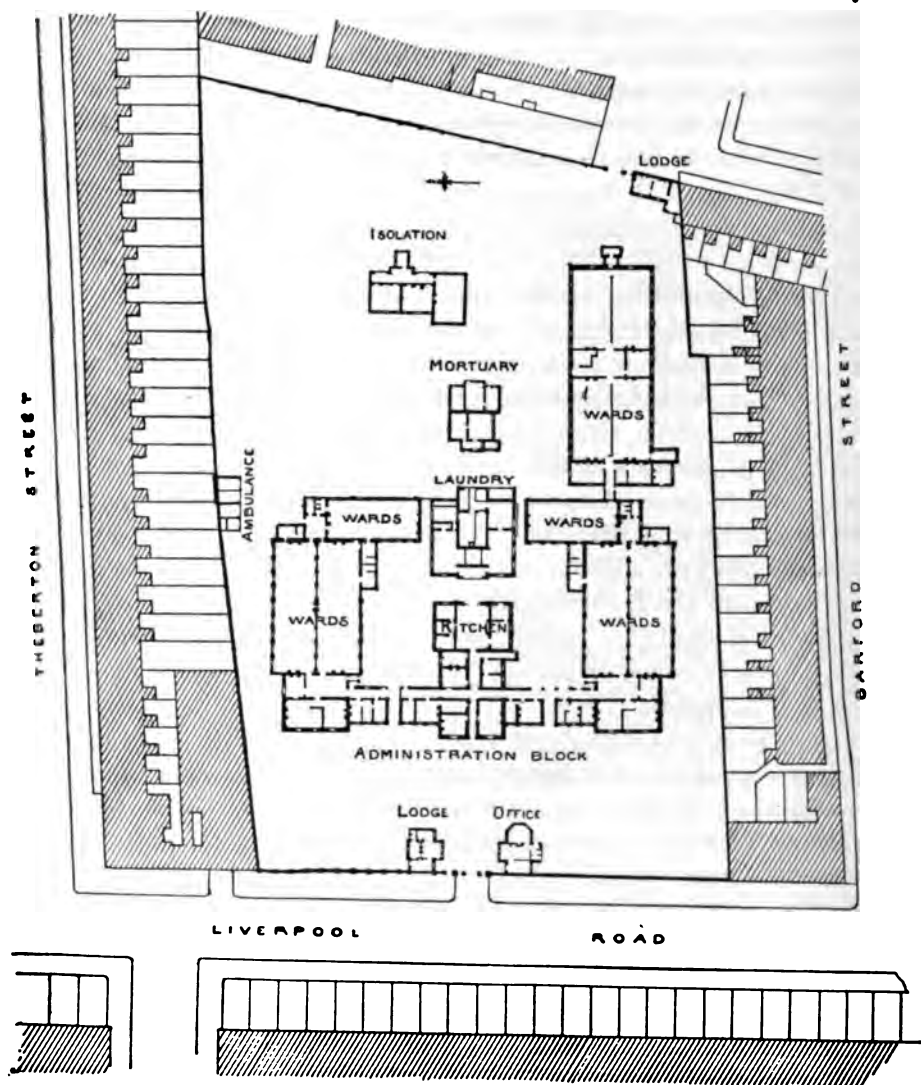
*School Sanatoria.*

Rugby School Sanatorium.

King Edward VI.'s School, New Sanatorium (Sherborne, Dorset).

Blundell's School, New Sanatorium (Tiverton, Devon).

## LONDON FEVER HOSPITAL LIVERPOOL ROAD. LONDON. N.



*Probationary Wards.*

In all infectious disease hospitals of considerable size it is desirable to establish probationary wards for the observation of doubtful cases. It is often very difficult to make a correct diagnosis at the outset of a case of infectious disease. Meanwhile great danger is incurred by the family or the household with whom the patient may be residing. It therefore is a matter of considerable importance to provide a place where the patient may be kept under such surveillance as will avoid danger to others, if the case proves to be infectious, and at the same time may avoid the infection of the patient if it so happens that his illness proves to be either non-infectious or a less dangerous disease.

*School Sanatoria, or Isolating Wards.*

A useful application of the system of infectious disease hospitals is found in its adaptation to the uses of large institutions of learning, or establishments of any sort in which young people are congregated, either for educational or for other purposes, away from their homes.

It is by no means a matter of uncommon occurrence for an outbreak of infectious diseases to take place among the inmates of institutions of this character. Such outbreaks invariably disturb the harmony of the college, school or other institution, and seriously interfere with the regular exercises. Many instances of such outbreaks are not only on record, but in some cases it has happened that the whole school or college population has been broken up and sent to their homes.

The existence of a single building, in which the first cases of infectious disease could be isolated and cared for until convalescence ensued, would in many instances have obviated much of this trouble.

Every large educational establishment should possess an isolating ward or hospital, which could in emergencies be used for this purpose.

While the infectious diseases of childhood are not so fatal nor so frequent among persons of school or college ages, their occurrence is yet sufficiently common among this class to require extreme care for their prevention, as the following figures will show.

The deaths from certain infectious diseases among persons between the ages of fifteen and thirty years in Massachusetts, during

the period of twenty-eight years ending with 1890, were as follows :—

|                            |       |
|----------------------------|-------|
| From measles, . . . . .    | 276   |
| “ scarlet fever, . . . . . | 763   |
| “ diphtheria, . . . . .    | 1,480 |
| “ small-pox, . . . . .     | 1,171 |

To the foregoing figures should be added the deaths from typhoid fever, a disease which finds its victims in the period fifteen to thirty years in the greatest numbers. The deaths from this disease at those ages for the same period in Massachusetts were 11,993.

Phthisis claims a much larger harvest from this age period than either of the foregoing diseases, the number of deaths being 57,197 for the same time and ages. In the case of phthisis, however, while its infectious character must be recognized, the peculiar nature of the disease unfits its victims for the continuance of prolonged study, and all such persons should be advised to discontinue their connection as soon as the nature of the disease is recognized.

Dr. Sykes concisely explains the differences between residential and non-residential schools with reference to the subject of isolation as follows :—

There is a strong contrast in the manner in which personal infection is spread in non-residential and residential schools. In non-residential schools children from various households meet at a centre, become infected, and returning, distribute the infection broadcast, closure being resorted to for the purpose of checking its spread. In residential schools, on the other hand, the infection is more or less confined to the limits of the school, and is only distributed beyond upon the disbandment of the pupils. Hence, it is interesting to note that opposite results may follow the similar process of closing a school, in the two cases, unless extreme precautions are taken.

Residential schools, like other residential institutions, protect themselves from admitting infected scholars from without by requiring certificates of freedom from infection, or from contact with infection, upon admission ; and, when invaded, from the spread of infection within, by isolation in proper quarters. Non-residential schools, where the attendance is daily, do not admit of the application of measures of protection in this form, and are dependent upon school-teachers immediately excluding from attendance children suffering from infectious disease, or being members of an infected family or household. This exclusion can only be enforced by the teacher or manager being informed by the parents or by the sanitary authority of



the cases of infectious disease occurring amongst the scholars. Compulsory notification is therefore a valuable protection to schools. If exclusion fails, and infection reaches a school, not directly but indirectly, by the commingling of infected with healthy children beyond the precincts of the school, it points to the absence of proper seclusion of the infected children at home or in hospital, and it is only when seclusion; as well as exclusion, fail to prevent an epidemic in a school that dissolution or closure of the school is justifiable. Defects of internal condition, structure or site liable to lead to such a result are naturally also included in such justification.

The memorandum\* issued in December, 1890, by the chief medical officer of the Local Government Board explains in a very full and lucid manner the measures necessary to be taken in this direction for the protection of "public elementary schools" by sanitary authorities.

#### SUMMARY.

The advantages of the separate hospital for infectious diseases may be summed up briefly, as follows:—

1. They allow the complete isolation of the sick in cases where the sick cannot be effectively separated at their homes.

2. The work of the wage-earner, the ordinary duties of the household and the school attendance of children can go on as usual without interruption.

3. Infection is thus kept by itself in a place where it can be intelligently treated and destroyed. Otherwise, in tenement-houses and crowded dwellings, and among those who are ignorant of its nature and its proper management and control, it may spread and cause infinite harm.

4. Cities requiring such hospitals should not wait for the hurried impetus derived from panic, but should construct carefully and thoroughly, and with due regard to their own special needs. Such hospitals, like fire departments, when completed should be always ready for immediate use. They should be accessible and under wise and intelligent management.

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\* Quoted in full in twenty-third annual report of State Board of Health, 1891, page xvi.

## APPENDIX.

## PRACTICE OF DIFFERENT COUNTRIES.

In the following pages are grouped some of the essential data relative to the progress of different countries in this particular direction for preventing the spread of infectious diseases.

For a portion of this information the writer is indebted to Dr. Palmberg's recent work entitled "Public Health in its Applications in Different European Countries."

## ENGLAND.

*Memoranda of the Local Government Board of England.**Regulations as to Hospitals (Memorandum on Hospital Accommodation).*

— Means for separating the sick from the healthy should always be provided. When two contagious diseases break out at the same time, they should each be separately isolated.

In towns, and for several villages of smaller size, there should be provided at least two special wards with four beds in each, in order that the sick may be isolated from the commencement. Such a very small infirmary would be very valuable for arresting the progress of an epidemic.

Fig. 1 represents a very simple type of hospital, having one ward for each sex, with the necessary annexa. This plan accompanies the memorandum of the Local Government Board.

Fig. 2 represents two sections of the same building, the one to the left having simple walls and serving for summer rooms; the one to the right having double walls is a permanent structure. At the base of the external walls are openings for the admission of fresh air, seen on the front of the elevation (Fig. 1). In the roof are other openings for the escape of foul air, but chimneys or special tubes are the best for this purpose.

In rural districts without a hospital, a trustworthy married couple without children may be charged with the isolation and care of cases of infectious disease. In the event of a more serious epidemic, several lodgings may be hired for the sick, or they may be isolated in temporarily erected tents or barracks.

Fever hospitals in urban districts ought to have one bed for every 1,000 inhabitants. In manufacturing towns with a very dense population, this proportion ought to be even greater; while in wealthy and less dense towns, with houses of a good class, one bed for every 2,000 inhabitants may suffice.

Permanent fever hospitals are built on the system of separate pavilions. There must be at least four wards for patients, as well as a pavilion for administration.

Sick wards can be arranged in pavilions connected in pairs, as shown in Fig. 3, which is taken from the memorandum of the Local Government

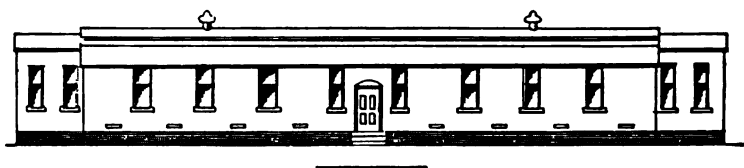
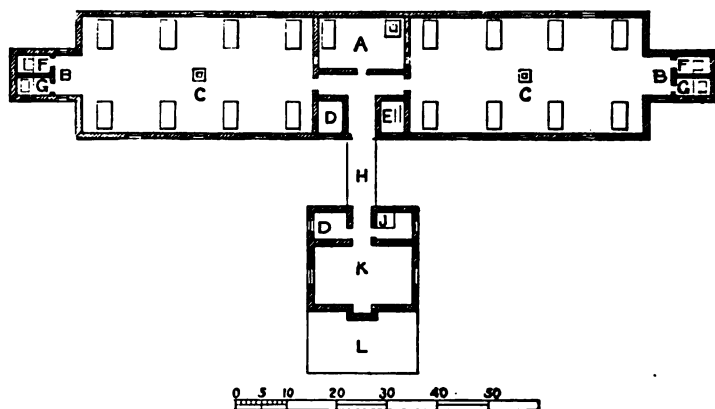


FIG. 1.—PLAN AND ELEVATION OF A SMALL HOSPITAL.



A. Small separate apartment. B. Passage connecting the two wards. C. Stove. D. Store-room. E. Bath-room. F. Water closets. G. Lavatories. H. Covered way. J. Coal-house. K. Kitchen. L. Space for additional buildings if required.

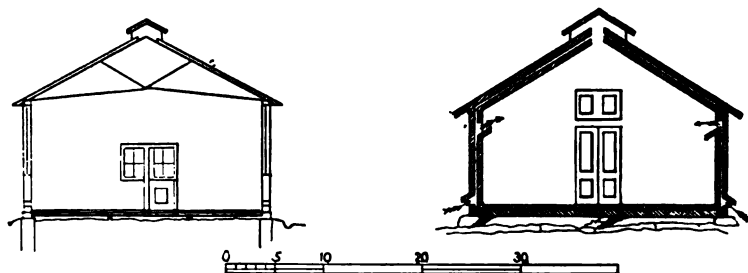


FIG. 2.—VERTICAL SECTIONS THROUGH SAME HOSPITAL.

Board. The dotted lines in this figure show how, as the population increases, the permanent hospital can be enlarged.

The minimum distance between the pavilions should be thirty feet.

Fig. 4 shows another arrangement of sick wards which is preferable when sufficient ground is available.

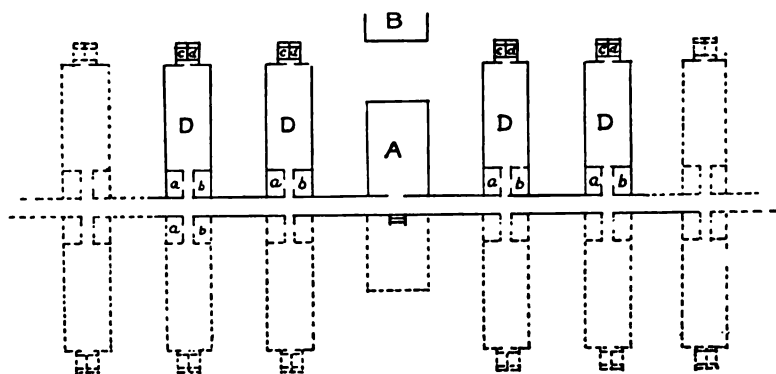


Fig. 3 - PERMANENT HOSPITAL IN PAVILIONS.,

The sick wards may also be placed on different stories of the same pavilion.

Two of them, one for each sex, are reserved for persons suffering from the same infectious disease.

All the wards should be kept separate, and independently warmed and ventilated. To facilitate the work of the staff a corridor connects all the

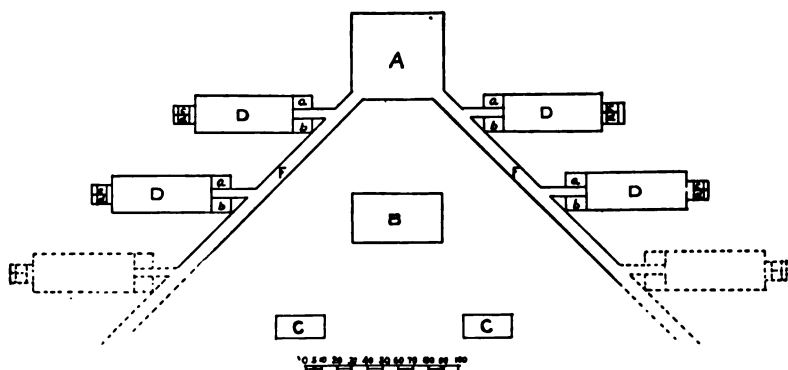


Fig. 4 - ANOTHER ARRANGEMENT OF PERMANENT HOSPITALS IN PAVILIONS.

A. Administrative building (kitchen, store, sleeping accommodation for nurses and servants). B. Laundry, etc. C, C. Disinfecting chamber and mortuary. E. Corridor. D. Wards for patients with ten beds in each, lavatory and bathroom (a, b) next the corridor; closets and sinks (c, d) at other end, separated from ward by a cross-ventilated corridor.

pavilions. The latter should be so placed that the air can circulate freely between them. The space between the pavilions should be at least one and a half times as great as the height of each pavilion; and if a pavilion is intended for small-pox, the distance should be still greater. It is preferable to place small-pox in an entirely separate building as remote as possible from all other buildings.

In wards for infectious diseases there should be openings for admission of fresh air between each bed, a little above the floor, so that pure air bathes the patient's bed. They should be furnished with a grooved fastening, so that the admission of air can be graduated. The openings for extraction of foul air should be near the ceiling, and as remote as possible from those admitting fresh air. They should, unless entering into the chimney-breast, be carried vertically to the roof and be provided with an aspirating cowl.

#### *Memorandum of Ambulances.*

For the conveyance of patients who are sick with infectious disease, special carriages or ambulances are necessary. The following points have to be attended to in the provision and use of such carriages:—

1. If the ambulance be intended only for journeys of not more than a mile, it may be made so as to be carried between two people, or it may be on wheels and to be drawn by hand. If the distance be above a mile, the ambulance should be drawn by a horse. Every ambulance on wheels should have easy carriage springs.
2. In the construction of an ambulance, special regard should be had to the fact that after each use, it has to be cleansed and disinfected. The entire interior, and the bed-frame and bed, should be of materials that can be washed.
3. The ambulance should be such that the patient can lie at full length in it; and the bed-frame and bed should be movable, so that the patient can be arranged upon the bed before being taken out of his house.
4. With an ambulance there should always be a person specially in charge of the patient; and a horse ambulance should have a seat for such person inside the carriage.
5. After every use of an ambulance for infectious disease, it should be cleansed and disinfected to the satisfaction of a medical officer.
6. Both in very populous districts, and in districts which are of very wide area, it may often happen that more than one ambulance will be wanted at one time; and in any district, if more than one infectious disease is prevailing, there will be an evident sanitary advantage in having more than one ambulance for use.

*Rules for Hospitals for Infectious Diseases.*

1. The medical officer is the responsible superintendent of the establishment. It is his duty to visit the hospital even at times when there are no patients, to ensure that the matron and nurse are at their post, and that everything is ready for the reception of patients.

2. The matron and head nurse ought to maintain the greatest cleanliness and to see that the beds are well aired, conveniently arranged, and always ready to receive patients. They ought also to keep the inventory of everything belonging to the hospital. They are forbidden to absent themselves together without express authority. They must carry out the orders of the doctor and be responsible for the conduct of the staff and the nurses.

3. The matron (or steward, if there is one, as in large hospitals) must be prepared monthly to present the books of accounts to the sanitary authority.

*Instructions for Nurses, Patients and Visitors.*

1. Every applicant for admission to a hospital should have a medical certificate of the disease from which he is suffering.

2. A patient can be attended by a doctor of his own choice other than the medical officer of the hospital at his own cost.

3. No person is admitted to the hospital without the permission of the medical officer.

4. No patient is permitted to leave the hospital until discharged by the medical officer.

5. The patient's clothes must be disinfected before being given up to him at his discharge.

6. Officers and servants of the hospital are not allowed to leave the hospital without authority of the medical officer; and they must first change their clothes.

The following table contains some of the most essential data relative to several of the hospitals embraced in Dr. Thorne's report. Values are expressed approximately, in United States equivalents, instead of English money.

*Statistics Presenting Cost of Construction of Isolation Hospitals and other Items.*

| DISTRICT.                     | Estimated Population. | Number of Beds. | Present Bed-rate per 1,000 of the Population. | Floor Space per Bed. | Ward Capacity per Bed. | COST OF                   |                              | Remarks.                                                                                                                                                                                                                   |
|-------------------------------|-----------------------|-----------------|-----------------------------------------------|----------------------|------------------------|---------------------------|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                               |                       |                 |                                               |                      |                        | Hospital, excluding Site. | Bed, excluding Cost of Site. |                                                                                                                                                                                                                            |
| Berkhamstead (rural), .       | 11,000                | 8               | 0.7                                           | 144                  | 2,000                  | \$10,525                  | \$1,315                      | The addition of a second pavilion will increase the number of beds to 16, the administrative building sufficing for the requirements of increased accommodation, and the cost per bed will then amount to less than \$875. |
| Cheltenham (urban), .         | 44,000                | 35              | 0.7                                           | 144*                 | 2,300*                 | 54,160                    | 1,690                        | When the total of 56 beds has been provided the cost per bed will be reduced to \$1,090.                                                                                                                                   |
| Darlington (urban), .         | 35,000                | 44              | 1.3                                           | 144-175              | 2,000                  | 49,300                    | 1,095                        | Ward extensions are provided for.                                                                                                                                                                                          |
| Folkestone (urban), .         | 18,700                | 14              | 0.7                                           | 140                  | 2,000                  | 13,635                    | 974                          | Two other pavilions to be erected containing together 22 beds. There is also a separate small-pox hospital with 4 beds, raising the present bed-rate to 0.9 per 1,000 population.                                          |
| Lewes (combined districts), . | 11,200                | 8               | 1.1                                           | 144                  | 2,000                  | 9,620                     | 1,200                        | Two thousand three hundred dollars were spent in excavations, etc., in connection with the site. There is no disinfecting apparatus.                                                                                       |
| Middlesbrough (urban), .      | 56,000                | 32              | 0.6                                           | 122-180              | 1,620-2,100            | 33,250                    | 1,037                        | This hospital, though constructed for 32 beds, actually contains 48. The cost per bed is calculated on the number it should properly contain. Enlargement of several existing wards is provided for.                       |
| Sheffield (urban), .          | 285,000               | 64              | 0.2                                           | 138                  | 1,810                  | 96,350                    | 1,505                        | Cost of preparing site was heavy; \$8,750 was thus expended.                                                                                                                                                               |
| Solihull (rural), .           | 20,000                | 12              | 0.6                                           | 144-156              | 2,000-2,184            | 14,085                    | 1,174                        | Walls of pavilions less substantial than desirable; some use made of materials already in hand.                                                                                                                            |
| Tonbridge (urban), .          | 10,000                | 12              | 1.2                                           | 140                  | 2,000                  | 6,290                     | 526                          | Two more pavilions to be erected. Over \$975 spent in providing an inefficient ambulance and disinfecting stove.                                                                                                           |
| Warrington (urban), .         | 42,000                | 28              | 0.7                                           | 144-175              | 2,038-2,529            | 31,920                    | 1,140                        | No enclosure wall deemed necessary. No disinfecter yet provided.                                                                                                                                                           |
| Weymouth (port), .            | -                     | 25              | -                                             | 144-169              | 2,014-2,028            | 25,000                    | 935                          |                                                                                                                                                                                                                            |

\* Average.

## GLASGOW.

The following description is quoted from the official report of the trustees of the Glasgow Fever Hospital:—

“The grounds possess great natural beauty, rising gently as you approach the Clyde, where they are broken by three small glens, once the beds and sloping banks of three streams. The whole estate is well wooded, especially along the avenue and western boundary, where the rooks have recently established themselves in the tops of the old beeches. The convalescents are allowed to wander at will over the many beautiful walks, and in the summer it is one of the most pleasant sights to see the children rolling about on the grassy slopes of the glens, and the seats, placed here and there, occupied by groups of people who for the first time in the lives of many are tasting of the sweets of Nature. At the rear of the fever hospital several acres are laid out as a flower garden, with a greenhouse, from which the wards are supplied with potted plants. Flower plots are distributed here and there between the pavilions and in other open spaces. At a distance of some four miles southward, the wooded heights of the Cathkin Hills close in the horizon.”

“The whole buildings, except that occupied by the medical and nursing staff and matron, are built of brick. The wards are distributed in pairs, in thirteen totally isolated pavilions, all running north and south. They are sixty feet apart laterally, and are placed in rows of two, three, four and five, in succession from the bank overlooking the Clyde towards London Road. They have thus, to one standing in their midst, the appearance of a large, uniformly laid-out village. Each pavilion is only one story in height, with a well-ventilated basement beneath, so that the level of the ward is reached by a flight of steps. The two rows of four pavilions are separated by a range of buildings running east and west, the centre of which contains the kitchen, one story in height, and, like the pavilions, open to the roof. At either end there is another story, the eastern accommodating various stores and the dispensary; the western, the under servants' rooms. At London Road there is a main lodge controlling to the west the entrance to the small-pox hospital, and to the east, the approach to the fever hospital. At the south end of this approach is the fever lodge and enquiry rooms for patients' friends, with the Dorcas Society's stores in an attic story, and running north along the avenue, the morgue, with room for funeral parties, with entrance from the road so that hearses, etc., do not come within the hospital enclosure. Just inside this gate is the washing-house and laundry, with the suite of steam boilers to the south, a cremator for soiled beds, and the central coal depot. The boilers are three in number, double-flued, and in size seven feet six inches by twenty-six feet four inches. Further south are a smithy, carpenters' shop and fire-engine station. Southwestward, some forty yards, are the stables, ambulance



shed, etc. Still westward is a large three-story stone block, erected on the site of the old mansion house, containing eighty-four single bed-rooms for nurses, with recreation rooms on each flat. These occupy the lateral wings, while the centre is reserved for the matron and medical staff. In front of this building there is a spacious lawn, with tennis court, bounded southwards towards the Clyde by a sloping bank planted with trees."

"There are three hundred beds on the scale of 2,000 cubic feet for adults; but as a large proportion of the patients are children, for whom 1,200 feet is sufficient, a much larger number of patients can be accommodated. The dimensions of every pavilion and ward are exactly the same; but as they were erected at different times, sundry little but important differences exist. The two southern pavilions were built last, and the description of one will suffice. It has a basement eight feet from ground to floor level. The outside length, from end to end, is one hundred and sixty-eight feet; the outside breadth, twenty-six feet; the height, from ground level to ridge of roof, thirty-two feet. There are two wards, each divided into a convalescent and acute ward. A flight of steps on both sides gives access to a vestibule, from which, on one hand, are the entrances to these subdivisions, while, on the opposite side, is the pantry, opening directly off the passage, and a lobby, to the left of which are the bath-room and water-closet, and to the right a steep-room for soiled linen, these last being farthest from the wards. All these appurtenances are therefore completely isolated in a projecting annex. The entrance and annex of each ward are on opposite sides of the pavilion. On the side opposite to the entrance of the acute ward is a nurse's duty room, where there is a 'poison press' and a napery press, with chairs and a table. The front projects into the ward with sloping roof and glass sides, giving a full view of the ward. The internal dimensions are as follows: acute ward, length, 56 feet 3 inches; convalescent ward, length, 24 feet. In both the breadth is 22 feet; the height to the wall head, 14 feet 6 inches; to the roof tree, 23 feet 9 inches. The floorage of the acute ward is 1,237 square feet; of the convalescent, 528 square feet. The total cubic contents of the acute ward are 23,500 cubic feet; of the convalescent ward, 10,000. The number of adult beds is eleven for the acute and four for the convalescent ward; but in the case of children twenty cribs are allowed."

"All the flooring of the wards is of Dantzic oak, waxed. The vestibule and annex are laid with tiles. The walls are coated with Keene's cement. Some wards are oil-painted and varnished, but the more recent are treated with light blue or green distemper, which can frequently be renewed. All the woodwork is varnished. Care is taken to avoid flat surfaces giving lodgment for dust. The principal rafters are, therefore, of light T iron, and the tiles of thin rod iron."

"The heating is by hot water circulating in pipes which are led round the walls above the floor. This is derived from two hot-water tanks heated

by steam, and placed beneath the entrance hall of each ward, to which access is obtained from the outside by a stair leading to the basement. There are also open fires at either end of each ward. Pavilions with numerous windows and open to the roof are very difficult to warm sufficiently during winter. Experience at Parliamentary Road soon showed that it would be necessary to check radiation by the large glass area, and accordingly the device of double glazing each pane with an interval of three-quarters of an inch of air space was adopted. The wards at Belvidere are kept at 55° to 60° in the coldest weather. There are heating coils in the vestibule and bathroom."

"Fresh air is admitted by direct openings beneath the windows, which are numerous, so that it passes over the heating pipes. These openings are controlled by an arrangement which admits of gradation, and cannot be interfered with except by the nurse. There are skylights on opposite sides of the slope of the roof, Boyle's ventilators fixed on the ridge, and ventilating shafts alongside the chimneys, with openings controlled by movable louvres and the apex of the roof."

"The principles kept in view in furnishing are simplicity, smooth surfaces and facility of removing and cleaning. The bedsteads are wrought iron, the tables and chairs hardwood, varnished. In the children's wards, iron cribs are provided, and pigmy forms and tables suited to their size. All cupboards, presses, etc., are movable on iron rollers, like American trunks. The mattresses are stuffed with straw, the pillows with chaff. They are renewed for every new patient and whenever soiled. Wood wool was recently tried as a substitute for straw, but was found speedily to break down, and, on account of the consequent expense and larger quantity and more frequent renewal, was not adopted."

"The nurses are graded in three classes—probationers, nurses and head nurses. After a year's probation, during which she attends lectures on fever nursing given by the assistant physicians, the probationer is submitted to a written and *viva voce* examination. If she passes satisfactorily, she gets a 'Certificate of Proficiency in Fever Nursing,' first, second or third class, signed by the physician superintendent, and becomes a nurse. The wage of a probationer is £18, and advances gradually to £30, all getting two uniform suits per annum for ward use alone. To work a purely pavilion hospital such as Belvidere, all its parts distributed over a large area, and to maintain the large extent of flower garden and pleasure ground attached, requires a large staff. The distribution of coals is done by an open lorry, on which all the coal-boxes are placed and driven round the wards. The food is distributed by a covered van, divided into compartments, each of which holds the allowance for a ward. The ashes are collected daily from portable circular-covered ashbins countersunk in the ground adjacent to each ward, an arrangement which combines convenience and perfect sightliness and inoffensiveness. The whole institution is under

the care of a physician superintendent, who is assisted in the general business of the hospital by a house steward, and in the medical charge by two permanent medical assistants. These are supplemented, as occasion requires, by extra assistants. In fact, there are seldom less than three assistants, and usually in the autumn and winter there are four or five. These appointments are in great request among the best students of the Glasgow school. They are only given to qualified men, and by preference to such as have been house surgeons in either of our infirmaries. They remain from one to two years. The present physician superintendent, Dr. J. W. Allan, was appointed in August, 1875, and has contributed much by his urbanity, good management and rich experience to win and to retain the confidence which Belvidere undoubtedly possesses both with the profession and the public."

"In calculating the cost of treatment, the expenditure on the small-pox hospital is always thrown in with that on the fever hospital. There having been only rare and isolated cases of small-pox for some years, 120 beds have been constantly used for scarlet fever, and only one pavilion, barricaded off with the whole administrative buildings, for small-pox. A small staff is maintained there. The last financial year for which the accounts are made up (June 1, 1886, to May 31, 1887) may be taken as an illustration of the expenditure, number and nature of cases treated, etc. There was not a single case of small-pox treated, but £558 were expended in the small-pox hospital; £15,945 in the fever hospital; 2,790 cases were treated, including 1,270 cases of scarlet fever, 504 of measles, 204 of enteric fever, 176 of whooping-cough, 87 of typhus, 134 of erysipelas, diphtheria, chicken-pox and puerperal fever, the balance being made up of nursing mothers and cases of mistaken diagnosis. The average residence over all was 43.3 days (which is high, owing to the regulation residence being eight weeks for scarlet fever); the average daily number of patients, 332; the average cost of treatment per patient, £5 18s. This does not include interest on capital expended in building and furnishing hospitals, but does include ground, annual and all current expenditure in maintaining the whole estate and working the hospitals. Taking one year with another, the average mortality is: for typhus, 13 per cent.; enteric fever, 12 per cent.; scarlet fever, 12 per cent.; measles, 5 per cent.; whooping-cough, 12 per cent.; and over all cases, 10 per cent."

"In the northeast corner of Belvidere estate, the central washing and disinfecting establishment for the city is situated, occupying an area of 2,500 square yards. In those times when the treatment of infectious diseases was left to the Royal Infirmary, whatever disinfection was carried out at the houses of the patients was also performed by the directors. In their annual report for 1824 they refer to this fact. The first washing-house established by the authorities was a small place with a few tubs in a close off the High Street. This was opened in 1864. When Belvidere was

acquired, half of the existing fever hospital washing-house was reserved for this purpose. This soon proved inadequate, and the present separate establishment was finished, in 1883, at a cost of £8,400. It is essentially a washing-house, fitted up with the best mechanical appliances, to which the articles to be treated are driven by a service of vans. There is a Lyons disinfector, in which mattresses, clothing, etc., which cannot be washed, are disinfected, a cremator for burning straw, chaff, wool, flock and other articles, 'whose end is to be burned,' and a carpet-beating machine. It has just been resolved to spend £800 in improving the arrangements, and especially in adding appliances, devised by the sanitary inspector, for treating everything which is ultimately to be washed with a solution of bichloride of mercury, which, it is expected, will make the articles innocuous before passing them on to the washers. On an average, 1,000 articles per day are treated in one way or another."

"The hospitals, the washing-house, and the sanitary office in the city are all in telephonic connection."

#### GERMANY.

The following regulations pertain to the organization of hospitals for infectious diseases in Germany.

A. The building must be isolated and situated in an open space, if possible, away from inhabited quarters, but at such a distance that the patients may be taken to it without difficulty or distress.

B. There must be no communication between the hospital and its surroundings, and, where necessary, complete isolation must be established.

C. The beds must be separated by at least seventy-five to ninety centimeters and each patient allowed fourteen cubic meters of space. (These requirements would hardly meet the demands of modern hospital hygiene.)

Convalescents are placed by themselves. Hospitals must be provided with spare wards so that the occupied wards may be vacated from time to time and carefully purified.

D. The air of the hospital must be kept fresh and pure. The furniture must be kept perfectly clean, as well as the rooms.

E. The clothing of the patients must be separately stored and carefully disinfected before it is returned to them.

F. Convalescents must be isolated till they leave the hospital.

#### BERLIN.

##### *Hospitals for Isolation.*

At Berlin the preventive measures against infectious diseases are organized according to the regulations in force throughout the Empire.

A large hospital for isolation has been built by the corporation, composed of twenty-four detached pavilions of one story, with an additional

building for emergencies. A space is reserved for the construction of six additional pavilions.

This hospital (das städtische Krankenhaus Moabit) is situated in a space nearly open on all sides on the Moabit quarter, near to the public park, and small Thiergarten. The ground has the form of an elongated rectangle. Pavilions are built on the long sides facing east and west. The distance between each is seventeen meters, and the two sides are separated by sixty-four metres. The intermediate space is occupied by lawns, groups of trees and shrubs.

The buildings cover a surface of 10,000 square meters, of which 6,432 are occupied by buildings; the grounds, mortuaries, etc., take up the remainder.

Each pavilion contains a ward 28.25 meters in length, 6.90 meters in width, and 3.14 meters in height. Each contains thirty beds—too many in a hospital for infectious diseases, as that allows only twenty-seven cubic meters for each patient. The ward is lighted by windows in the side walls, one being placed between every two beds.

The materials employed in the construction are blocks of wood intercalated with bricks. The inside walls are lined with boards painted in oil a bright color. The floor is formed of a bed of concrete.

There are no ceilings. The roof is composed of a double layer of boards, painted in oil inside and covered outside with millboard saturated with asphalt.

A skylight runs along the middle of the roof with lateral apertures, which may be opened and shut from within.

A vestibule at one end, traversed by the entrance corridors, comprises on its right side servants' rooms and the dispensary, and on the left, the bath-room, linen-room and water-closets. All these rooms have boarded floors.

The heating is effected by means of steam-pipes connected with a boiler, which also serves for the kitchen and laundry. A large steam-pipe runs in a subterranean trench in front of the pavilions, sending a branch to each, which is subdivided into several pipes for warming the rooms and heating water for the bath-room. Three steam-pipes, two to the north and one to the south, run above the floor at a height of 0.30 meters; they are provided with taps for the regulation of the temperature. The condensed water returns to the boiler by a pipe.

Ventilation is very simply managed. Fresh air is introduced by means of fourteen openings, each eighteen centimeters wide, made in the walls of each ward at the same height as the steam-pipes, which warm the air as it enters. The impure air escapes by the lateral apertures above.

The rooms, etc., are lighted with gas; the lamps are hung below the skylight, and assist in the ventilation.

The pavilion for special isolation attached to the hospital is similarly constructed and measures 15.67 meters in length by 8 meters in width, and

3.64 meters in height. It contains three rooms separated from one another, each having three beds. A covered veranda, 2.30 meters in height, runs along the front. Large doors at each end set up a current of fresh air.

Eleven casements are placed in front of the veranda near the roof, which are removed during the summer.

A water-closet is provided for each room, placed in a vestibule, and abutting on an outside wall, being perfectly ventilated and separated from the ward by an ante-chamber.

Each of the wards has a roof of a pyramidal form, at the top of which is a ventilating-pipe surmounted with a Wolpert aspirator. The floors are made of brick covered with Metlach mosaic.

Heating is effected by steam introduced into hot-air stoves, placed in the middle of the floor, and so constructed that the heat can be regulated. The stoves are surrounded with an iron jacket.

Fresh air is supplied to the apparatus by a trench in masonry under the floor, and is warmed in passing between the stove and the jacket. The impure air escapes partly by the ventilating pipe in the roof, partly by other pipes adjoining a small tower in the ceiling of the veranda, in which are placed water-cisterns for the baths.

The rooms may also be heated by steam-pipes.

At one end of the veranda is a small enclosed room, into which linen for the wash is thrown through a trap-door; it is taken away by a door communicating with the open air.

There is a place for disinfection in the establishment through which the linen is passed.

When no epidemic prevails, part of the hospital is given up to ordinary patients. It is, however, considered preferable to nurse the latter in the städtische allgemeine Krankenhaus Friedrichshain, which is a splendid hospital built in pavilions, four of which have one story and six two stories. There are also two pavilions for isolation with two stories and another of one story exclusively reserved for diphtheritic patients.

In the department for isolation each adult is allowed a space of fifty-seven to sixty cubic meters, and each child thirty-one to forty-two cubic meters.

The pavilion for diphtheria is warmed by steam, but the general method is a combination of heating by means of hot-water apparatus connected with the ventilation. Each ward has also chimneys open in the summer and autumn.

In order to assist ventilation the smoke-pipes pass through the ventilating shaft.

The removal of persons suffering from infectious diseases is entrusted to contractors charged with the maintenance of the necessary carriages, the use of public carriages being forbidden to such patients in virtue of an official order of the 7th of February, 1887.

## PARIS.

No satisfactory system for the treatment of persons sick with infectious diseases in hospitals specially designed for this purpose has yet been effected, but a commission was appointed to investigate the subject, and reported in June, 1887, to the municipal council. Thus far, persons attacked with infectious diseases have been received into all hospitals, except small-pox patients, who were only admitted to the hospitals of Saint Louis and Saint Antoine, which had isolated buildings for their accommodation. In the other hospitals the infected are also isolated, but experience has proved that the measures taken for that purpose have not been effectual, and it too often happens that infection is propagated within these establishments. Statistics also show that there has been an increase in the deaths from infectious diseases in Paris, while they have sensibly diminished in other cities where isolation is better organized.

There is a station at the Hotel Dieu in connection with the transport of infectious cases, in which are kept two horses, two carriages and a driver. When any person ill with a contagious disease requires to be taken to the hospital, notice is sent to the nearest police station, whence it is transmitted to the Prefecture, who then sends orders to the Hotel Dieu. The disinfection of carriages is prescribed by the regulations, but this duty is left to the driver, without supervision.

The plan already mentioned provides for two ambulance stations, one on the right bank of the Seine, near the Hospital of St. Antoine, and the other on the left bank, near the Hospital for Sick Children. Each of these stations is to have twelve carriages for removal of the sick. Two will be reserved for small-pox, two each for measles, diphtheria, scarlet fever and typhoid fever, and the last two will be reserved for other diseases— whooping-cough, erysipelas, etc. The carriages used for one disease are never to be used for another. Each coach-house must be divided into six compartments in order to prevent mistakes. The stable will be arranged for six horses, though it will not be necessary to keep more than two in them under ordinary circumstances.

A certain number of nurses will be assigned to each ambulance to accompany the patients. They will live in the adjoining hospital and give their services in turn.

The staff of the station will consist of a chief officer, two coachmen, one of whom must be married, and a servant, who may be the wife of the latter. All these persons will live on the premises, and the staff, as well as the nurses, will be boarded there. The estimated cost of construction of each station is about \$14,000, and that of each carriage about \$500. Each is to be provided with a seat for the nurse, near the pillow of the patient, and a drawer for clothes and linen. After each journey the carriage is to be thoroughly washed. The stations are to be connected by telephone with the Relief Board and the Prefecture.

*Hospitals.*

As a part of this general plan, four hospitals are to be erected near the gates at the entrance of the city. Two will be devoted to small-pox, and one each to diphtheria and to measles. The first are designed for seventy beds in each. The plan provides for reserving a plat of ground near by, so that in case of need supplementary pavilions may be constructed with accommodations for more than eighty more patients. This ground is to be levelled, covered with asphalt and drained, so that temporary buildings can be put up in a few days. If further accommodation is required, it is proposed to build a hospital for convalescents at Creteil, southwest of Paris, on ground belonging to the Relief Board.

A hospital for diphtheria also forms a part of the plan, to be erected near Bicêtre, at the south end of the city.

The following figures show the special need for arresting the progress of diphtheria and measles in Paris :—

*Mean Death-rate from Diphtheria per 10,000 Inhabitants, Paris.*

|                    |           |      |
|--------------------|-----------|------|
| From 1865 to 1869, | . . . . . | 4.32 |
| " 1870 to 1874,    | . . . . . | 4.72 |
| " 1875 to 1879,    | . . . . . | 8.88 |
| " 1880 to 1884,    | . . . . . | 9.26 |
| " 1885 to 1887,    | . . . . . | 7.68 |

*Mean Death-rate from Measles per 10,000 Inhabitants, Paris.*

|                    |           |      |
|--------------------|-----------|------|
| From 1865 to 1869, | . . . . . | 3.18 |
| " 1870 to 1874,    | . . . . . | 3.35 |
| " 1875 to 1879,    | . . . . . | 3.72 |
| " 1880 to 1884,    | . . . . . | 4.90 |
| " 1885 to 1889,    | . . . . . | 5.71 |

Scarlet fever does not appear to have found a congenial soil in Paris, the average mortality per 10,000 from this cause being but 0.9 as compared with 1.7 in London, 1.2 in Edinburgh and 3.2 in Berlin. Measures for its restriction there do not therefore appear to be so imperative as in the case of the infectious diseases already named.

With the view of diminishing the spread of whooping-cough it has also been proposed to found a great isolating establishment, including a school and a hospital.

The public disinfecting stations form a part of the general plan for the prevention of the spread of infectious diseases. Those of Paris and Berlin are most thoroughly equipped, and managed in the most effective and systematic manner. Their description, however, does not come within the scope of the present paper.



Later information upon the subject of isolation of contagious diseases in Paris may be found in a paper contributed to the International Congress of Charities, Correction and Philanthropy at Chicago in June, 1893, by Drs. Herbert and Hogg of Paris.\*

The following summary is presented in that paper of the facilities which are afforded in Paris for the isolation and treatment of hospital patients suffering with contagious diseases. The hospitals providing such facilities are six in number : —

The *Aubervilliers Hospital* possesses separate buildings for small-pox, measles, scarlet fever, erysipelas, diphtheria and doubtful cases ; in all, 184 beds.

The *Hospital Trousseau*. Isolation wards are established for children with diphtheria, measles and scarlet fever (181 beds).

*Hospital "des Enfants Malades"* (Enfants Jésus), which is a hospital for children, receives diphtheria and scarlet fever patients (52 beds).

In addition to these the following hospitals are provided with isolation rooms : *Lariboisière*, 7 beds ; *La Pitié*, 5 beds ; *La Charité*, 3 beds.

All of these taken together furnish a total of 332 beds.

#### SWEDEN.

In Sweden, local public health administration is in charge of a Commission of Hygiene, in the towns (Helsövardsnämnd) ; and in rural districts the Communal Council is entrusted with sanitary functions. These have been organized by laws of 1874 and 1885.

During the prevalence of an epidemic of infectious disease the Commission must attend to the following regulations : —

1. The immediate removal of the patient to a special hospital, a place isolated for the purpose, unless the transport should endanger the life of the patient. He may remain in his own dwelling if he can be nursed according to the regulations prescribed by the Commission.

2. The immediate disinfection of the house, clothing, bedding, etc., of the patients who have died, recovered or been sent to the hospital.

3. Patients are not to be removed in public carriages ; stretchers, sedan chairs, etc., are disinfected after use.

4. Clothing of the patients, and anything belonging to the hospital which has been lent or sold, are to be disinfected.

Persons suffering with epidemic or infectious diseases cannot refuse to be removed to the special hospital unless life would be endangered, or they can be nursed in a place properly isolated, at their own expense.

When two infectious diseases prevail at the same time, two special hospitals should be established, or, at least, a properly isolated portion must be set apart for the treatment of one class of patients.

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\* Hospitals, Dispensaries and Nursing. Papers, Discussions, etc., at Congress of Charities, Correction and Philanthropy, June, 1893. New York, 1894.

*Stockholm.*

Population about 225,000. In Stockholm the plan presented in 1884, by Dr. Linroth, Chief Medical Officer, for the purpose of organizing the treatment of infectious diseases in the city includes —

1. A hospital placed at one end of the city, organized in a pavilion system, and comprising —

|                                                                              |          |
|------------------------------------------------------------------------------|----------|
| A building for small-pox, with . . . . .                                     | 20 beds. |
| A building for typhus fever, with . . . . .                                  | 20 “     |
| A building for scarlet fever, with . . . . .                                 | 35 “     |
| A building for diphtheria, with . . . . .                                    | 28 “     |
| A building for measles, with . . . . .                                       | 35 “     |
| A building with, at least, ten small observation rooms, each having one bed. |          |

A building for the staff, containing also rooms for the medical officers of the establishment.

Buildings for offices, such as kitchen, laundry, place for disinfection and the burning of straw, stables, coach-houses and ice-houses.

A place should be reserved on the same ground for two temporary hospitals, the plans and drawings for which must be quite ready so that they can be erected without delay in case of need.

2. A branch establishment at the other end of the city, organized after the same system, and comprising —

|                                                            |          |
|------------------------------------------------------------|----------|
| A building for scarlet fever, with . . . . .               | 30 beds. |
| A building for measles, with . . . . .                     | 25 beds. |
| A building for the staff, and two rooms for special cases. |          |
| A building for the offices of the establishment.           |          |

3. An establishment situated in the group of islands on this side of Vaxholm, intended to receive infectious patients who have arrived by sea, and comprising a pavilion with fifteen beds; a place for disinfection; a building for the staff and officers.

4. A place for disinfection within the city for the healthy members of families exposed to infection, and for suspected clothing. The number of beds available should be one hundred and forty-eight in the large hospital, fifty-seven in the branch establishment and fifteen in the island hospital, in all two hundred and twenty beds.

Dr. Linroth is of opinion that typhoid fever may safely be treated in the other hospitals of the city as in previous years.

The construction of a new isolation hospital on the above plan was only begun in 1890. The hospital comprises five pavilions, comprising altogether one hundred and sixty-two beds, a building with eight observation

rooms, a building for the administration and for the doctor, one for cooking, a laundry, mortuary, etc.

Before this time the old hospitals were utilized, temporary buildings being erected for special requirements.

These are constructed of double boards. The interstices of the walls, floor and ceiling are filled up with charcoal.

A barrack on this model was erected in ten days in the park of Bellevue near Brunsviken, when an epidemic of small-pox was threatened. The expense amounted to about £700.

A permanent erection has been constructed on the ground of the hospital Saint Maria to serve as a place for isolation. Its total length is 32.30 meters and the width 7.50 meters. Its height is 15.50 meters between the ground and the ridge. The front, which looks towards the west, is flanked by a fore-court eight meters in length by 5.5 meters in width. The sides are made of boards 7.5 centimeters thick, wainscoted and lined with mill-board outside and inside. The roof is of mill-board covered with asphalt.

The building contains two wards, with thirteen beds in each. The space between the wards is occupied by a room for the nurse, a linen-room, and a small kitchen for making drinks. Behind the vestibule adjoining the wards, which can be divided into parts, is a fore-court in which are placed the latrines and the bath-room. The floors of the wards are made of asphalt, laid on a bed of cement, which is placed on the ground, covered with a bed of broken stones and gravel. The other rooms have also asphalt floors, excepting the nurses' room.

The walls and ceilings are painted in oil throughout the building, in order that they may be easily cleaned. Each bed in the wards has 7.20 square meters of floor space and 30 cubic meters of cubic space. The windows are made in the side wall of the ward, and look east and west, there being eleven in each ward. The windows are two meters in height by one in breadth, their total surface being about one-fourth of the floor. The establishment possesses a gas and water service. There are two baths made of copper in the bath-room. The latrines are arranged on the system of movable tanks used in the city, but in such a way that the urine flows away separately by a subterranean pipe. In the closets there are also cisterns in zinc for the soiled linen, a current of water continuously passing through them from top to bottom, and discharging into the sewer. The speed of the current is regulated at pleasure.

In this way all risk from the handling of dry linen worn by the infectious patients is avoided. The linen is not taken from the water and wrung until the moment when it is to be sent to the wash. The cisterns have lids locked with a key.

Heating and ventilation are effected by means of a kind of stove with an iron casing lined with fire-proof bricks. The casing does not come higher

than the middle of the stove, and is 6 centimeters from it. The total height of the apparatus is 3.60 meters, the exterior diameter, 0.60 meter; the heated surface, 7 square meters.

The fresh air, entering by a pipe sixty centimeters by thirty, arrives at the bottom of the stove and is heated in passing between the stove and the casing. The ventilating-pipe is provided with a sliding valve.

The stoves are arranged for slow combustion, fed at long intervals during the day, and kept locked.

The impure air escapes by pipes heated in the chimney, each discharge pipe having an opening near the floor for ventilation in winter and one under the ceiling for summer; the valves of these openings are enclosed that they may be out of reach of the patients.

The upper sash of two opposite windows in each ward is provided with hinges below, so as to open within, and has an iron plate on each side.

All the air-pipes are arranged so as to be easily cleaned.

During the summer more thorough ventilation may be secured by a water ventilator on Trentler and Schwartz's systems, fixed in the roof, above the centre of the building. This ventilator is put into communication with the wards and the outer air in such a way that air may be admitted or excluded at pleasure by opening or shutting valves.

The cost of this barrack is about £1,440.

The city keeps a special carriage for the removal of infectious patients. It is lined inside with varnished wood, which can be easily cleaned after each journey.

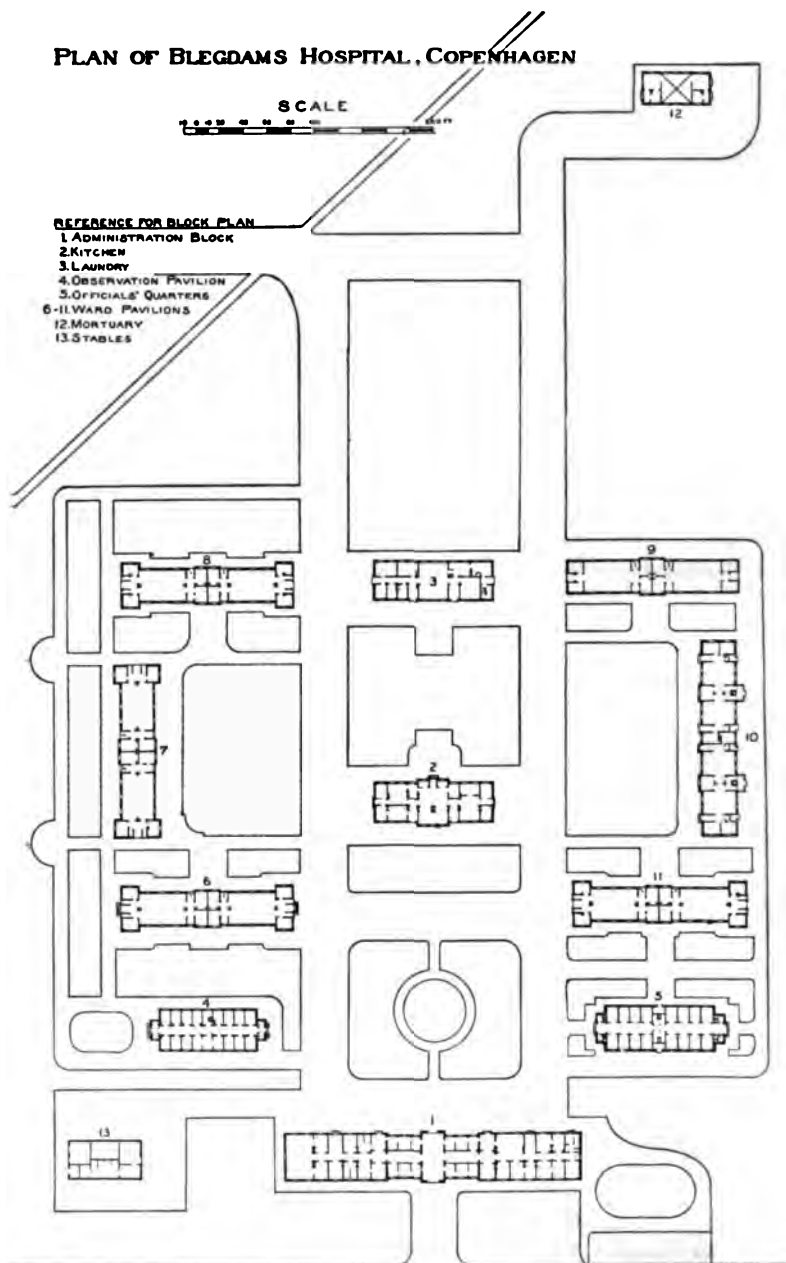
#### DENMARK.

##### *Copenhagen.*

The wards of Blegdams Hospital are fitted up with special care for the treatment of patients with infectious diseases. There are eight one-storied pavilions, two for twelve patients each, six for twenty-six each, and a two-storied pavilion for seventy-eight patients; besides, there are some movable marquees (felt tents of Docker's patent), with accommodations for fifty patients. The general arrangement of the hospital is shown in the accompanying plan. The one-storied pavilions belong to several systems. One of these is especially distinguished by its heating and ventilating system, planned by Mr. Julius Thomsen, Professor of the University and President of the Polytechnic Academy. In outline it is in each of two entirely similar halves, as follows: fresh air is conducted from wells at a proper distance from the building to an air chamber in its cellar, from which it is conducted under the floor of the sick ward, into which it ascends through three openings in the floor. In the cellar a fire is kept up all the year round; during the cold season the draught from the furnace is conducted to a chimney in the centre of the building through a calorifere placed in the air-chamber; hereby the fresh air gets a suitable temperature, while the

draught in summer is conducted directly to the chimney, without passing the calorifere. The chimney will always thus be able to exhaust the vitiated air of the sick ward, which is effected by means of channels leading

PLAN OF BLEGDAMS HOSPITAL, COPENHAGEN



to the chimney from openings in the walls of the ward at various heights from the floor. The draught in the fireplace, in which the consumption of fuel naturally varies according to outside temperature, can be regulated with a simple mechanism from the cellar, as well as from the sick ward, so that it goes partly through the calorifere, partly directly to the chimney, and that an increase of one passage corresponds to a diminishing of the other. In the same manner the exhaust can be regulated; its strength can be read from an anemometer in the ward, and it may be regulated or entirely stopped, according to circumstances. The nurses are thus at all times able to control the temperature and renewal of air. The above-mentioned two-storied sick ward of Blegdams Hospital was just completed at the expiration of 1890, and represents a high-class modern-hospital technique. The principles on which the new operating room in the Commune Hospital, above described, was built are in every essential also used in this building. Its baths, kitchens, closets and other accessories are in most perfect harmony with the principles described above.

## III.

The following summary embraces the returns of diseases "dangerous to public health" made to the State Board of Health under the provisions of chapter 302 of the Acts of 1893. Since the act in question did not specify the diseases intended to be reported to the Board (except small-pox), the Board issued a circular, in which it expressed its opinion as to the particular diseases which should be reported under the provisions of this act. They were the following: *small-pox, scarlet fever, measles, typhoid fever, diphtheria, membranous croup, cholera, yellow fever, typhus fever, cerebro-spinal meningitis, hydrophobia, malignant pustule, leprosy and trichinosis.*

The report of 1893 embraced the returns of the fractional year only which immediately followed the enactment of the statute, while those of 1894 were for a full year.

The whole number of cases of infectious diseases reported in 1895 was 21,307, which were divided as follows:—

|                                                   |        |
|---------------------------------------------------|--------|
| Reported cases of small-pox, . . . . .            | 1      |
| Reported cases of diphtheria and croup, . . . . . | 7,806  |
| Reported cases of scarlet fever, . . . . .        | 6,194  |
| Reported cases of typhoid fever, . . . . .        | 2,438  |
| Reported cases of measles, . . . . .              | 4,868  |
| Total, . . . . .                                  | 21,307 |

The summary for the years 1893, 1894 and 1895 is as follows:—

|                   | REPORTED CASES OF |                       |                |                |          |
|-------------------|-------------------|-----------------------|----------------|----------------|----------|
|                   | Small-pox.        | Diphtheria and Croup. | Scarlet Fever. | Typhoid Fever. | Measles. |
| 1893, . . . . .   | 35                | 1,109                 | 2,914          | 1,525          | 1,303    |
| 1894, . . . . .   | 181               | 4,178                 | 6,731          | 2,372          | 2,133    |
| 1895, . . . . .   | 1                 | 7,806                 | 6,194          | 2,438          | 4,868    |
| Totals, . . . . . | 217               | 13,093                | 15,839         | 6,335          | 8,504    |

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# HEALTH OF TOWNS.

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## HEALTH OF TOWNS.

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Under this title it has been customary to present a digest of the annual reports of the local boards of health which have been received at the office of the State Board of Health.

Very few of the smaller towns (such as have populations of less than 2,000 inhabitants) publish separate reports of the local boards of health. The reports which we receive are, therefore, mainly those of the cities and large towns.

The most prominent topics which appear in these reports are the increased care devoted to the subject of the notification of infectious diseases, and their prevention by isolation, disinfection and vaccination, the need of sewerage and efficient methods of disposal in towns where no systems are in existence, the inspection of plumbing and registration of plumbers, and the disposal of the garbage and the refuse of houses and of streets.

The subject of the notification of diseases has been considered at an earlier place in this volume.

The following table contains the statistics of cases of diphtheria, scarlet fever, typhoid fever and measles reported to local boards of health, as compiled from the annual reports of such boards, which have been forwarded to the office of the State Board, since the close of the calendar year 1893. In parallel columns are also presented the deaths from the same causes, as given in the same reports.

*Certain Infectious Diseases reported to Local Boards of Health in 1893.*

| CITIES AND TOWNS.       | DIPHTHERIA AND CROUP. |         | SCARLET FEVER. |         | TYPHOID FEVER. |         | MEASLES. |         |
|-------------------------|-----------------------|---------|----------------|---------|----------------|---------|----------|---------|
|                         | Cases.                | Deaths. | Cases.         | Deaths. | Cases.         | Deaths. | Cases.   | Deaths. |
| Amesbury, . . . . .     | 13                    | -       | 89             | 14      | 21             | -       | -        | -       |
| Attleborough, . . . . . | 21                    | 5       | 30             | 1       | 12             | -       | 91       | -       |
| Ayer, . . . . .         | -                     | -       | 37             | -       | 5              | -       | 3        | -       |
| Beverly, . . . . .      | 9                     | 1       | 7              | -       | 14             | 2       | -        | -       |

*Certain Infectious Diseases reported to Local Boards of Health in 1893*  
— Continued.

| CITIES AND TOWNS.           | DIPHTHERIA AND CROUP. |         | SCARLET FEVER. |         | TYPHOID FEVER. |         | MEASLES. |         |
|-----------------------------|-----------------------|---------|----------------|---------|----------------|---------|----------|---------|
|                             | Cases.                | Deaths. | Cases.         | Deaths. | Cases.         | Deaths. | Cases.   | Deaths. |
| BOSTON, . . . . .           | 1,465                 | 476     | 2,580          | 248     | 824            | 148     | -        | -       |
| Bradford, . . . . .         | 5                     | 1       | 8              | -       | 6              | 1       | 5        | -       |
| Bridgewater, . . . . .      | 2                     | -       | 3              | -       | 2              | -       | -        | -       |
| BROCKTON, . . . . .         | 44                    | 15      | 82             | 5       | 20             | 3       | 111      | -       |
| Brookline, . . . . .        | 18                    | 4       | 44             | 7       | 10             | 3       | 515      | 6       |
| CAMBRIDGE, . . . . .        | 103                   | 48      | 680            | 67      | 92             | 16      | -        | 11      |
| CHELSEA, . . . . .          | 29                    | 10      | 89             | 7       | 10             | 5       | -        | -       |
| Concord, . . . . .          | 7                     | -       | 38             | -       | 4              | -       | 43       | -       |
| Dedham, . . . . .           | 3                     | -       | 53             | 3       | 9              | 2       | 47       | -       |
| Easthampton, . . . . .      | 34                    | 11      | 16             | -       | -              | -       | -        | -       |
| EVERETT, . . . . .          | 10                    | 2       | 105            | 11      | 12             | 4       | 147      | 5       |
| FALL RIVER, . . . . .       | 40                    | 13      | 343            | 32      | 87             | 17      | -        | -       |
| FITCHBURG, . . . . .        | 10                    | 3       | 28             | -       | 23             | 4       | 592      | 7       |
| Framlingham, . . . . .      | 13                    | 2       | 32             | 1       | -              | -       | 38       | -       |
| Gardner, . . . . .          | 4                     | -       | 9              | 1       | 18             | 1       | 50       | 2       |
| GLOUCESTER, . . . . .       | 16                    | 9       | 110            | 5       | 7              | 5       | -        | -       |
| Great Barrington, . . . . . | 4                     | 2       | 27             | 1       | -              | -       | -        | -       |
| Greenfield, . . . . .       | 47                    | 5       | 9              | -       | 10             | 4       | -        | -       |
| HAVERHILL, . . . . .        | 18                    | 3       | 97             | 6       | 53             | 12      | 26       | -       |
| Hingham, . . . . .          | 2                     | -       | 29             | 4       | -              | -       | -        | -       |
| Hudson, . . . . .           | 4                     | 2       | 14             | 1       | 14             | 6       | 13       | -       |
| Ipawich, . . . . .          | 5                     | 1       | 19             | 1       | 5              | -       | 20       | -       |
| LAWRENCE, . . . . .         | 85                    | 19      | 241            | 81      | 141            | 33      | 60       | 3       |
| Leominster, . . . . .       | 20                    | 2       | 33             | 1       | 6              | 1       | 264      | -       |
| Lexington, . . . . .        | 1                     | 1       | 2              | -       | 2              | -       | 154      | -       |
| LOWELL, . . . . .           | 85                    | 30      | 209            | 18      | 160            | 53      | 541      | 10      |
| LYNN, . . . . .             | 105                   | 38      | 272            | 9       | 63             | 12      | -        | -       |
| Marblehead, . . . . .       | 15                    | -       | 113            | 5       | 7              | -       | -        | -       |
| MAHLBOROUGH, . . . . .      | 7                     | 6       | 14             | -       | 2              | 7       | 316      | 3       |
| Maynard, . . . . .          | 1                     | -       | 43             | 2       | -              | 3       | 13       | -       |
| MEDFORD, . . . . .          | 28                    | 7       | 31             | 5       | 13             | 6       | 300      | 1       |
| Melrose, . . . . .          | 15                    | 3       | 93             | 5       | 5              | -       | 92       | -       |
| Millbury, . . . . .         | 10                    | 1       | 14             | -       | 15             | 3       | 118      | 2       |
| Milton, . . . . .           | 4                     | -       | 10             | -       | 2              | -       | 27       | -       |
| Nantucket, . . . . .        | 0                     | -       | 0              | -       | 0              | -       | 0        | -       |
| Needham, . . . . .          | 3                     | -       | 4              | -       | 11             | 3       | 1        | -       |

*Certain Infectious Diseases reported to Local Boards of Health in 1893*  
— Concluded.

| CITIES AND TOWNS.         | DIPHTHERIA AND CROUP. |         | SCARLET FEVER. |         | TYPHOID FEVER. |         | MEASLES. |         |
|---------------------------|-----------------------|---------|----------------|---------|----------------|---------|----------|---------|
|                           | Cases.                | Deaths. | Cases.         | Deaths. | Cases.         | Deaths. | Cases.   | Deaths. |
| NEW BEDFORD, . . . .      | 26                    | 13      | 222            | 8       | 234            | 29      | 125      | 5       |
| NEWBURYPORT, . . . .      | 35                    | 8       | 6              | 1       | 57             | 7       | 23       | 0       |
| NEWTON, . . . . .         | 89                    | 33      | 115            | 2       | 23             | 4       | 548      | 1       |
| NORTHAMPTON, . . . .      | 15                    | 5       | 77             | 12      | 49             | 4       | 26       | 1       |
| North Andover, . . . .    | -                     | -       | 4              | -       | 2              | -       | 3        | -       |
| North Attleborough, . . . | -                     | 2       | -              | 14      | 4              | 3       | -        | -       |
| Northbridge, . . . . .    | 9                     | -       | 1              | -       | 1              | -       | -        | -       |
| Orange, . . . . .         | -                     | 1       | 1              | -       | 6              | 2       | 32       | -       |
| PITTSFIELD, . . . . .     | 7                     | 1       | 164            | 4       | 20             | 5       | 98       | 2       |
| Plymouth, . . . . .       | 61                    | 22      | 8              | 1       | 13             | -       | -        | -       |
| QUINCY, . . . . .         | 15                    | 4       | 97             | 3       | 29             | 10      | 252      | 2       |
| Reading, . . . . .        | 1                     | -       | 3              | -       | 3              | 1       | 23       | -       |
| Revere, . . . . .         | 8                     | 1       | 16             | 2       | 6              | 1       | -        | -       |
| Rockland, . . . . .       | 2                     | 1       | 17             | -       | 1              | 1       | 34       | -       |
| SALEM, . . . . .          | 47                    | 13      | 79             | 1       | 52             | 11      | -        | -       |
| Saugus, . . . . .         | -                     | -       | 1              | -       | 1              | -       | 43       | -       |
| SPRINGFIELD, . . . . .    | 48                    | 22      | 285            | 24      | 52             | -       | -        | 10      |
| Swampscott, . . . . .     | 5                     | 2       | 11             | -       | -              | -       | -        | -       |
| TAUNTON, . . . . .        | 9                     | 6       | 181            | 10      | 10             | 7       | -        | -       |
| Wakefield, . . . . .      | 21                    | 6       | 33             | 3       | 10             | 5       | 53       | -       |
| WALTHAM, . . . . .        | 35                    | 12      | 132            | 3       | 25             | 2       | -        | -       |
| Ware, . . . . .           | 11                    | 5       | 15             | -       | 1              | 1       | 17       | 8       |
| Wellesley, . . . . .      | 2                     | -       | 8              | -       | -              | -       | 48       | -       |
| Westborough, . . . . .    | -                     | -       | 4              | -       | -              | -       | -        | -       |
| Westfield, . . . . .      | several               | 1       | several        | -       | several        | 6       | -        | -       |
| Westford, . . . . .       | 2                     | 1       | 8              | -       | 1              | 1       | 15       | 3       |
| Williamstown, . . . . .   | 6                     | 1       | 8              | 4       | 7              | 3       | 1        | -       |
| Winchester, . . . . .     | 4                     | 1       | 15             | 2       | 12             | 4       | 250      | -       |
| WOBURN, . . . . .         | 32                    | 8       | 73             | 9       | 9              | 1       | -        | -       |
| WORCESTER, . . . . .      | 123                   | 38      | 179            | 10      | 143            | 31      | 1,112    | 16      |
| Totals, . . . . .         | 2,919                 | 926     | 7,420          | 654     | 2,457          | 492     | 6,290    | 98      |

From the comparison of these figures, the relative fatality of each disease during the year in these cities and towns may readily be ascertained. The columns of deaths may be considered as quite accurate, while the reported cases are probably somewhat less than

the actual numbers, in consequence of a small percentage of neglect or failure to report. The figures are as follows :—

|                                                        |                |
|--------------------------------------------------------|----------------|
| Reported cases of diphtheria and croup, . . . . .      | 2,919          |
| Registered deaths from diphtheria and croup, . . . . . | 926            |
| Fatality, . . . . .                                    | 31.7 per cent. |
| Reported cases of scarlet fever, . . . . .             | 7,420          |
| Registered deaths from scarlet fever, . . . . .        | 654            |
| Fatality, . . . . .                                    | 8.8 per cent.  |
| Reported cases of typhoid fever, . . . . .             | 2,457          |
| Registered deaths from typhoid fever, . . . . .        | 492            |
| Fatality, . . . . .                                    | 20.0 per cent. |
| Reported cases of measles, . . . . .                   | 6,290          |
| Registered deaths from measles, . . . . .              | 98             |
| Fatality, . . . . .                                    | 1.6 per cent.  |

The following summary contains the figures for each of these diseases for the years 1891, 1892 and 1893 :—

*Reported Cases of Infectious Diseases.*

|                           | DIPHTHERIA AND CROUP. |       |       | SCARLET FEVER. |       |       | TYPHOID FEVER. |       |       | MEASLES. |       |       |
|---------------------------|-----------------------|-------|-------|----------------|-------|-------|----------------|-------|-------|----------|-------|-------|
|                           | 1891.                 | 1892. | 1893. | 1891.          | 1892. | 1893. | 1891.          | 1892. | 1893. | 1891.    | 1892. | 1893. |
| Reported cases, . . . . . | 2,444                 | 3,033 | 2,919 | 4,517          | 6,112 | 7,420 | 2,414          | 1,892 | 2,457 | 5,861    | 783   | 6,290 |
| Deaths, . . . . .         | 575                   | 891   | 926   | 151            | 281   | 624   | 460            | 435   | 492   | 84       | 31    | 96    |
| Fatality, . . . . .       | 23.5                  | 29.2  | 31.7  | 3.3            | 4.6   | 8.8   | 19.0           | 23.0  | 20.0  | 1.4      | 4.0   | 1.6   |
| Mean of three years,      | 28.5                  |       |       | 6.8            |       |       | 20.5           |       |       | 1.6      |       |       |

The cities and towns embraced in this list were 70 in number, and comprised about three-fourths of the population of the State. They were nearly identical with those which furnished reports in 1892.

The number of reported cases of diphtheria was eighty less than that of 1892, and the percentage of fatal cases was slightly larger.

The reported cases of scarlet fever exceeded those of 1892 by 1,308, while the fatality was 8.8 per cent. or nearly double that of the preceding year.

The reported cases of typhoid fever were greater than those of 1892 by 565, but the fatality was less, being 20 per cent. as compared with 23.0 in the preceding year.

The reported cases of measles were eight times as many as those of 1892, but the fatality was less than half as great, being 1.6 per cent. as compared with 4.0 in the preceding year.

The following figures present the fatality from diphtheria, scarlet fever and typhoid fever as reported by the Local Government Board of England for the years 1890, 1891 and 1892.

|                          | 1890. | 1891. | 1892. |
|--------------------------|-------|-------|-------|
| Diphtheria, . . . . .    | 25.5  | 23.7  | 23.6  |
| Scarlet fever, . . . . . | 8.0   | 5.8   | 4.4   |
| Typhoid fever, . . . . . | 19.9  | 20.8  | 17.8  |

#### AMESBURY.

There have been many less complaints entered this year than last, eighty-two cases as against one hundred and fifty. Most of these were promptly abated on the attention of the property owners being called to the unsanitary conditions, therefore little expense was incurred to have official notices served.

There was some delay in abating the odor from the old soap factory, but the exigencies of the business made it almost unavoidable.

The Board would again call the earnest consideration of the voters of the town to the utility and economy of sewerage the town, as per plan now on file; if not the whole, at least a part should be done every year.

Scarlet fever at first showed itself in a mild form, but has gradually assumed a more malignant type, with a death rate of sixteen per cent. of reported cases. To stay the spread of this dread disease, the Board has promptly placarded every house in which the disease has been reported, and given full instructions as to the importance of isolation and proper disinfection. Some physicians and most heads of families have been dilatory in reporting the cases, and some were not reported at all. The State law requires such reports to be made, and imposes heavy fines for neglect. The school committee had the public schools closed for some weeks to stay the progress, but with no perceptible benefit, as two days before re-opening them there were seven new cases reported. The necessity of isolation in this disease is beyond question, and the all important step to be taken, if followed by efficient disinfection.

Two cases of supposed glanders in horses have been reported to the Board, one case being imported. The matter was immediately investigated by the Board and a veterinary surgeon from Boston, and the animal was satisfactorily disposed of at the phosphate factory.

## ARLINGTON.

In the absence of a regularly elected Board of Health, the selectmen, under the statutes, constitute the Board. As our town increases in population, and dwellings are erected nearer together, the importance of an alert and competent Board of Health is evident. On all our streets a greater or less portion of the land is used for cultivation. This results in the use of various forms of fertilizers, which, while not always dangerous to health, are very objectionable — whole neighborhoods at times being rendered uncomfortable by the unloading of the refuse from the city.

The keeping of swine within the limits of the town should be restricted to places remote from the densely inhabited portions.

We suggest that a separate Board of Health be elected by the town, selected from those citizens who are especially familiar with sanitary matters.

## ATTLEBOROUGH.

In accordance with the requirements of the Public Statutes, the Board of Health makes an annual report to the town. This report should include an account of the duties performed by the members, such suggestions for the physical welfare of the town as occur to them as the results of their experience, and tables of vital statistics which, when compared with reports of former years, indicate the way the town is growing and suggest opportunities for its sanitary improvement.

Less complaints were received this year than usual. In fact, householders are now generally informed as to the requirements of the Board and gladly conform to them. No serious epidemic has occurred.

Measles became so prevalent that the Board requested the school committee to exclude from the public schools all pupils coming from homes where there were such cases. This, being an innovation, caused unfavorable criticism from the public and even from physicians in town, but singularly enough, by this action the local Board only anticipated by a few months what is now required by the statutes, viz., that measles shall be included in the list of diseases "dangerous to the public health," and consequently to be especially guarded against.

## AYER.

The most notable occurrence in connection with the health of the town, during the year, was an epidemic of scarlet fever. The lower grades of the public schools were closed for several weeks in December with little apparent effect in checking the spread of the disease. The disease was probably spread in many instances by cases so mild they were not recognized.

## BARRE.

It is a notable fact relative to the health of Barre, that, in a total of thirty-five births and thirty-six deaths, there were no deaths of infants, and no death was reported of any person under thirty years of age.

## BEVERLY.

There was free vaccination of 1,374 patients, and the issuing of certificates to the same.

In view of the fact that the town has voted to put in a system of sewerage, the Board would most earnestly recommend that the town adopt the State plumbing law so that in the future the citizens will receive the full benefit of the sewer.

They would also call attention to the daily increasing demand for the adoption of some system for the collection of garbage, swill and ashes. At the present time the greater part of the swill is mixed with ashes and then dumped on some of the various dumps in and about the town, thus creating a very undesirable state of affairs in such locations.

## BOSTON.

The total number of deaths during the year was 11,710, an increase of 474 over the preceding year. The death-rate per 1,000 inhabitants for the year is found to be 24.02. The prevalence of pneumonia during the year assumed a character unequalled in the registration of vital statistics in this city. In 1851 its percentage to the total mortality was 7.75; in 1893 it was 13.15 per cent., or a total of 1,540 deaths from this cause alone. It is gratifying, however, to be able to state that the percentage of the total mortality from zymotic causes is less by .49 per cent. than for the year 1892, or 17.43 per cent. of the total number of deaths. The deaths from diphtheria increased 62, while the deaths from scarlatina decreased 14, as compared with the preceding year.

*Infectious Diseases.*

*Small-pox.* — On Oct. 30, 1893, after an interval of fourteen months, a case of small-pox occurred in Ward 6. The patient, a boy eleven years old, who arrived in Boston, October 15, on the "Catalonia," must have contracted the disease on that steamer. On November 6 a second case occurred. The case was found in Ward 22, and was directly traceable to the "Catalonia." This patient was removed to the hospital, and as he was unvaccinated he had a severe attack of the disease. This case gave rise to two others occurring in this man's family. As the two last patients had been vaccinated they were not very ill, and remained at the hospital only a short time. On November 13, in Ward 13, three cases occurred in one family, which were



directly traced to a mild attack of the disease which must have been contracted on the "Catalonia." These three patients, together with the person who arrived on the "Catalonia," were removed to the hospital, where they all recovered. The unvaccinated were quite ill; the vaccinated were not seriously ill. On November 18 a case occurred in Ward 14. The patient, a little girl about three years old, contracted the disease from a mild case in a person who arrived in Boston on the "Catalonia." On December 7, 8 and 9 eight cases occurred in Ward 19, which were contracted from an unrecognized and mild attack of the disease. A case occurred on December 8, in Ward 18, the origin of which could not be traced. From Dec. 10, 1893, to Jan. 5, 1894, eleven cases occurred which could be directly traced to the mild case in the family living in Ward 19, which has been previously mentioned. On December 13 a case occurred in Ward 14, which could be directly traced to a previous case.

From Oct. 30, 1893, to Jan. 31, 1894, there were in all thirty-six cases. The percentage of deaths among the unvaccinated has been 29.62. No vaccinated person has died, and no vaccinated person has been seriously ill. A mother nursed her infant, who had the disease, during the whole course of the attack, but as the mother had two perfectly characteristic scars she did not contract the disease. Two vaccinated children, relatives of a patient, were constantly exposed from three to four weeks to the disease and did not become ill.

*Vaccination.* — The number of cases of small-pox having increased in November, it was thought best to offer free vaccination in those sections of the city where cases of this disease were most frequently found, and there were in round numbers 100,000 vaccinated.

Early in November, while vaccinating among school children in South Boston, the Board personally discovered the fact that many children were attending the public schools without ever having been vaccinated, and these facts were subsequently communicated to the School Committee, under date of Nov. 28, 1893. Fifty-nine thousand four hundred and eighty-eight pupils have been examined; there have been 4,120 primary vaccinations; 10,152 re-vaccinations; and the number of pupils refusing vaccination and presenting insufficient evidence of having been vaccinated is 1,678.

*Diphtheria.* — The Board of Health has repeatedly asked for an appropriation with which to increase its care for the uncontrolled cases of diphtheria and scarlet fever, and it has as often been refused. The Board would like to have all cases seen by its own physicians or agents, held under proper surveillance while at home, and released from isolation only on the certificates from the same physicians or agents. We would like to aid in having all doubtful cases of sore throat decided by expert bacteriological examinations, and have all cases of diphtheria discharged from isolation by means of the same tests, or after a prolonged isolation when all local and general symptoms of the disease have disappeared. To do this the department

must have more medical agents, and have its present medical officers relieved from duties now performed for other departments of the city.

We have long since been satisfied that the welfare of the schools and the community at large demands better protection against the spread of contagious diseases, and that through additional medical agency alone can we hope to give such protection.

For this purpose the Board of Health recommended to the School Committee the adoption of the following regulations in response to a request from the School Committee:—

First: That no pupil be admitted to any public schools without a certificate from \_\_\_\_\_ that such pupil bears the physical evidence of having had a disease known as vaccinia.

Second: For the return of any pupil to school after suffering from small-pox, scarlet fever, diphtheria, measles, or whooping-cough, a certificate should be required from \_\_\_\_\_ that the pupil has lost all power to communicate to others the disease from which he has been suffering, and that all infected articles of his household have been disinfected to the satisfaction of the Board of Health. For the continuance of any pupil in school in whose family or in whose proximity there is a case of small-pox, scarlet fever, diphtheria, or measles, or any undestroyed infection or contagion from said diseases, there should be required a certificate from \_\_\_\_\_ setting forth the fact that the patient is safely removed from the danger of contracting and of conveying the disease.

When a child is known to have been exposed to the infection of small-pox, scarlet fever, diphtheria, or measles, it should return to school only on certificate of \_\_\_\_\_ that the period of incubation belonging to the disease to which he has been exposed has passed.

#### *Houses Vacated.*

During the year one hundred and eighteen houses have been ordered vacated for various causes, the chief complaints being general unsanitary conditions and want of repair. These houses were for the most part tenement-houses located in different sections of the city.

#### *Tenement and Lodging House Inspection.*

During the night visits of the inspectors the present winter, many cases of overcrowding were discovered in tenement-houses in the poorer sections of the city.

This the Board has been obliged to remedy by ordering the removal of all the occupants of such tenements, as it is obviously impossible for the Board to determine which ones should be allowed to remain, and which compelled to go. This difficulty, however, was in many cases solved by the occupants themselves, and as soon as the number of occupants became reduced to a satisfactory limit the Board rescinded its order to vacate the

premises if other sanitary requirements were complied with; in a few instances, however, the premises had to be entirely vacated before a satisfactory condition was reached.

The cheap lodging-houses have been frequently visited, and in most cases all requirements of the Board were complied with.

*House to House Inspection.*

|                                                       |       |
|-------------------------------------------------------|-------|
| Whole number examined, . . . . .                      | 382   |
| Bad odors found in, . . . . .                         | 83    |
| Defective drains found in, . . . . .                  | 122   |
| Defective trapping found in, . . . . .                | 107   |
| Privy-vaults found, . . . . .                         | 3     |
| Offensive vaults found, . . . . .                     | 3     |
| Damp or unclean yards, . . . . .                      | 8     |
| Damp or unclean cellars, . . . . .                    | 14    |
| Using furnaces, . . . . .                             | 190   |
| Furnaces without proper air-supply, . . . . .         | 18    |
| Using steam-heat or hot water, . . . . .              | 28    |
| Water-closets found in, . . . . .                     | 377   |
| Offensive water-closets found in, . . . . .           | 18    |
| Ventilation to soil-pipe or drain found in, . . . . . | 250   |
| Offensive cesspools found, . . . . .                  | 13    |
| Percentage of defective drains, . . . . .             | 31.94 |
| Percentage of defective trapping, . . . . .           | 28.01 |
| Percentage of unventilated drains, . . . . .          | 34.55 |

*Pollution of Charles River.*

In the fall of 1892 a complete inspection and report were made by a corps of inspectors from this office of all the drainage which was a source of pollution to the Charles River. This report includes all that part of the river located in Ward 25, and embraces not only the public sewers but also all private drains, the discharges from which, either directly or indirectly, eventually find their way into the river. At the time of inspection, in 1892, there were 232 private drains reported as discharging directly or indirectly into the river.

*Public Baths.*

The following table shows the number of bathers at the public baths:—

|                                  | 1892.     | 1893.     |
|----------------------------------|-----------|-----------|
| Total men and boys, . . . . .    | 908,889   | 825,614   |
| Total women and girls, . . . . . | 216,947   | 181,864   |
| Total of both sexes, . . . . .   | 1,125,836 | 1,007,478 |

*Disinfection.*

The following tables show the work of disinfection during the year : —

|                                          |       |                               |       |
|------------------------------------------|-------|-------------------------------|-------|
| Diphtheria, . . . . .                    | 1,307 | Infected books, . . . . .     | 23    |
| Scarlet fever, . . . . .                 | 2,235 | Infected carriages, . . . . . | 28    |
| Typhoid fever, . . . . .                 | 3     | Cancer, . . . . .             | 2     |
| Measles, . . . . .                       | 17    | Miscellaneous, . . . . .      | 2     |
| Small-pox, . . . . .                     | 20    |                               |       |
| Infected clothing and bedding, . . . . . | 79    | Total, . . . . .              | 3,716 |

Number of rooms, 6,429.

|                      |        |                          |         |
|----------------------|--------|--------------------------|---------|
| Streets, . . . . .   | 429    | Water-closets, . . . . . | 9,522   |
| Places, . . . . .    | 743    | Passageways, . . . . .   | 5,510   |
| Courts, . . . . .    | 564    | Urinals, . . . . .       | 389     |
| Alleys, . . . . .    | 3,803  | Vacant lots, . . . . .   | 525     |
| Yards, . . . . .     | 17,415 | Filthy sheds, . . . . .  | 7,509   |
| Vaults, . . . . .    | 4,413  | Filthy rooms, . . . . .  | 2,965   |
| Cellars, . . . . .   | 10,656 | Sinks, . . . . .         | 9,739   |
| Cesspools, . . . . . | 18,723 |                          |         |
| Gutters, . . . . .   | 11,004 | Total, . . . . .         | 103,909 |

Material used: bichloride of mercury, 1,550 pounds; chloride of lime, 54 casks; sulphur, 31,671½ pounds; copperas, 22 barrels; and 7 barrels of other disinfecting powder.

*Nuisances.*

The total number of nuisances abated during the year is 8,447.

In addition to the foregoing there have been 930 complaints investigated where action by the Board was found to be unnecessary.

*Report of Physician to the Board of Health.*

There have been 4,332 persons vaccinated, and certificates of vaccination have been given to 3,416 children for their admission to the public schools.

At the request of the Civil Service Commission three hundred and eighty-eight men have been examined for appointment in the Police and in the Fire Departments.

The bodies of six hundred and nineteen persons dying without a physician in attendance have been examined. These cases comprise principally those who die from chronic diseases, where there has been no medical care for months previous to death, and those who die suddenly from natural causes. In these a careful external examination is made, the symptoms learned, and a diagnosis, sufficiently accurate for all practical purposes, reached.

Ninety-six cases of eruptive disease reported as small-pox have been examined. Of these, twenty-six were found to be small-pox, and the patients—five men, thirteen women and eight children—were removed to the small-pox hospital on Canterbury street, where twenty-two recovered. The manifest importance of a bacteriological investigation as a means of diagnosis in doubtful cases of diphtheria is becoming more and more evident, and of no less importance, as far as the well-being of the community is concerned, is the bacteriological investigation of cases after apparent recovery from diphtheria. In an endeavor to diminish the prevalence of this disease, the two most important factors are: first, the recognition of mild and doubtful cases; second, the actual disappearance of the specific germs of the disease, which can only be recognized by means of a bacteriological investigation.

*Report of Port Physician.*

During the entire year all vessels arriving from the following ports were stopped at this quarantine for inspection: from all ports in Europe; from the Western, Madeira, Canary, or Cape Verde islands; from the Mediterranean sea or straits thereof; from the west coast of Africa or around the Cape of Good Hope, and from Central and South America.

From the first of June, vessels from the West India, Bahama, or Bermuda islands, and Mexico were stopped for inspection.

From the first of June to the first of November, all vessels arriving from any port in the United States south of Virginia were inspected at this quarantine.

Eight hundred and sixty-one vessels were boarded during the year.

Number of vessels disinfected, eight; one of which was a schooner and the remainder were steamers.

Number of persons removed from vessels for sickness, seventeen.

Number of persons vaccinated, 2,855.

The new bath-house and disinfecting cylinder were used for the first time April 1, and they both worked satisfactorily.

*Report of Inspector at Abattoir.*

*Animals Killed.*

|                   |               |
|-------------------|---------------|
| Cattle, . . . . . | 34,521        |
| Calves, . . . . . | 6,540         |
| Sheep, . . . . .  | 63,029        |
| Total, . . . . .  | <hr/> 104,090 |

*Animals Condemned.*

|                             | Number. | Weight. |
|-----------------------------|---------|---------|
|                             |         | Pounds. |
| Cows, . . . . .             | 29      | 12,437  |
| Steers, . . . . .           | 4       | 3,140   |
| Bulls, . . . . .            | 2       | 1,700   |
| Calves, . . . . .           | 6       | 270     |
| Sheep, . . . . .            | 3       | 130     |
| Parts of animals, . . . . . | —       | 2,500   |
| Total, . . . . .            | 44      | 20,177  |

*Tuberculosis.*

Fifty cases of tuberculosis were detected among adult cattle.

The following table shows the percentage of tuberculosis among cattle killed with the intention of being used for food : —

| CLASS OF ANIMALS.                              | Number<br>Received. | Tuberculosis. | Percentage. |
|------------------------------------------------|---------------------|---------------|-------------|
| Whole number of all kinds, . . . . .           | 34,521              | 50            | 0.14        |
| Cows from eastern states, . . . . .            | 2,014               | 44            | 2.18        |
| Cows from western states, . . . . .            | —                   | 3             | —           |
| Cows known to be from Massachusetts, . . . . . | 1,350               | 39            | 2.88        |
| Steers from western states, . . . . .          | —                   | —             | —           |
| Oxen from eastern states, . . . . .            | —                   | 2             | —           |
| Bulls, . . . . .                               | —                   | 1             | —           |

*Inspection of Cattle.*

The work of inspection of cows, as provided for by the Board of Health, and subsequently made compulsory upon cattle in general by an act of the legislature, has been continued during the past year. There are within the city limits about 2,400 cattle, distributed in about 690 barns ; all of these have been visited and the cattle in each, whether new or old, have been examined. Of the above-mentioned animals, seven have been pronounced suspicious, and the State Board of Cattle Commissioners notified that the same had been isolated. In making the above examinations, cattle have been found existing in all conditions and places. There are within the city limits people keeping a few cows, from two upward, who have not the

slightest idea of cleanliness, and practise little or none in the production of milk. Unfortunately a great many of such people are dependent on the sale of milk for a livelihood.

#### BRADFORD.

One case of tuberculosis has been reported, which was at once sent to the Cattle Commissioners, and the cow isolated as required by them and was, after examination by them, ordered to be killed.

The following regulation was drawn up and accepted by the Board and posted by them in accordance with the Public Statutes.

Regulation 40: No person shall keep swine or goats within the compact part of the town without a license from the Board of Health; and no swine shall be kept within three rods of any dwelling elsewhere.

There have been seventy houses where new plumbing has been done, and the inspector has thoroughly examined and accepted the same.

It is our advice that the town employ responsible parties, who shall, at stated intervals, collect the ashes and take charge of the dumping places, and that a contract be made with some responsible party to collect the swill and garbage as often as twice a week.

#### BRAINTREE.

By provision of law in towns not having a Board of Health, the selectmen act as such, having all the authority bestowed upon such Board. As the town is becoming more densely populated, stricter attention should be paid to the sanitary conditions.

We believe that the carrying of curtains or canopies from house to house as is sometimes the custom of funeral undertakers is a frequent source of contagion, and the practice should be discountenanced.

#### BROCKTON.

The following is a list of the principal complaints and nuisances investigated during the year:—

|                                 |     |
|---------------------------------|-----|
| Defective cess-pools, . . . . . | 102 |
| Defective vaults, . . . . .     | 65  |
| Filthy yards, . . . . .         | 115 |
| Houses placarded, . . . . .     | 126 |

The number of loads of cess-pool matter removed by the excavator wagons the past year was 12,210; the number of loads of night-soil removed was 3,099; the number of loads of ashes removed was 5,444.

The Sewerage Commissioners have completed the part of the work laid out for the year 1893, and, if as successful in carrying out their plans for sewerage the streets, will be able to take care of the sewage of the business part of the city the coming year.

A requisition was made upon the Civil Service Board of Examiners for a list of plumbers qualified for the position of inspector of plumbing. The names of three persons qualified to fill the position were certified to this Board, and one was selected and appointed by the Board as inspector of plumbing.

#### BROOKLINE.

The number of deaths reported from tuberculosis during the year (thirty, or over 12.5 per cent. of all the deaths, occurring principally as consumption), shows the need on the part of the public of a clearer understanding of the preventable nature of this too common disease. It may not be out of place to emphasize the fact that pulmonary tuberculosis (consumption) is absolutely proven to be a communicable disease, and quite easily communicated when the person exposed to it has his vitality depressed by such influences as foul air, indoor occupation, food poor in quality or insufficient in quality, bad ventilation, certain climatic conditions and especially fatigue from nursing a consumptive.

In April, the following order was passed : —

*Ordered*, That in case of death, when the deceased has not been attended by a physician, the certificate of death shall be issued by the Medical Examiner.

The public swimming-bath on Boylston street was open as usual during June, July, August and September. Early in the season the portion of the brook above the bath-house was inspected and cleaned out, and measures were taken to prevent pollution of the stream. Some necessary repairs were made on the bath-house to enable it to be used a little longer. Supt. Dillon reports that during the season 9,790 baths were taken, an increase of 2,101 over the previous year. Neither accidents nor illness have been reported, and many boys have learned to swim.

The importance, as a health measure, of frequent bathing in hot weather, and the great value of a public swimming-bath, both as a means of physical culture and of acquiring an art the possession of which saves many lives, can hardly be overestimated. The recommendation made last year by the committee on the bath-house is renewed, namely, that a more commodious swimming-bath be constructed.

The occasional need of a suitable building, owned by the town, for persons taken ill with diphtheria, scarlet fever or other dangerous contagious diseases (except small-pox) and having no home here, has received careful attention and it was

*Voted*, That in the opinion of the Board, it is necessary to erect a separate building upon land owned by the town, adjacent to the almshouse, for the care and treatment of patients with contagious diseases.



The emergency hospital for cases of small-pox, built by the Board in 1885, and fortunately never needed until 1893, was put in condition for patients, and, most important of all, ample facilities were provided for free vaccination.

Of the nine hundred and seventy-five persons who received free vaccination between December 1 and January 31, a very large proportion were natives of the British Provinces and never previously vaccinated. A number of alleged cases of small-pox, and of persons reliably reported as recently exposed to that disease, were promptly but quietly investigated by the Board, and all necessary precautions were taken in each case.

#### CAMBRIDGE.

Complaints and nuisances investigated during the year : —

|                                                             |        |
|-------------------------------------------------------------|--------|
| Full, overflowing and offensive privy vaults, . . . . .     | 733    |
| Offensive and defective water-closets, . . . . .            | 28     |
| Defective drainage, open and broken drains, etc., . . . . . | 61     |
| Filthy yards, . . . . .                                     | 118    |
| Number of inspections made, . . . . .                       | 6,368  |
| Number of subsequent inspections, . . . . .                 | 4,020  |
| Total, . . . . .                                            | 10,388 |

|                                                                                            |       |
|--------------------------------------------------------------------------------------------|-------|
| Number of notices issued and recorded, . . . . .                                           | 1,070 |
| Number of visits to premises where contagious diseases occurred during the year, . . . . . | 1,644 |

The various dumps throughout the city have caused considerable annoyance and given rise to many complaints during the year. With a view to a more thorough control of the persons using these dumps and for the prevention of the deposit of improper material on them, the Board decided to employ a mounted police officer for as long a time as the appropriation at their disposal would permit. The short experience the Board has had with this means of prevention, has convinced it of its value.

Owing to the occurrence of some cases of small-pox in neighboring places, the Board decided to open three stations for free vaccination. Following is a list of vaccinations done up to the close of the year : — Station One, seventy-one ; Station Two, two hundred and four ; Station Three, one hundred and fourteen.

An unusual prevalence of scarlet fever, or of diphtheria, always raises a question of the expediency of closing the public schools. Setting aside the fact that Boards of Health have not this power, it does not appear as if such a proceeding would answer any useful purpose in the majority of cases in such a city as Cambridge. Any plan calculated to control effectively the spread of such diseases as scarlet fever and diphtheria must include the following measures : —

1. *Isolation.* Hospital accommodation will be required for those cases which cannot be properly isolated at home.

2. *Disinfection.* Carpets, bedding, clothing and such like articles can be disinfected by steam. This requires a proper plant.

3. Articles of little value that have been exposed to contamination should be burned.

4. The floor and woodwork of rooms should be well scrubbed with soap and hot water. Walls, ceilings, chairs, bedsteads and such other pieces of furniture should be thoroughly wiped with damp cloths, and the cloths burned.

5. Windows should be left open for several days. Fresh air and sunlight are among the most effective of purifiers

Burning sulphur, or the evolution of chlorine fumes, is a useful adjunct, but they cannot take the place of the measures mentioned above, and to rely on them is, in our opinion, a grave mistake. Disinfection means a process by which disease-producing micro-organisms are killed. It does not mean deodorization, nor does it mean the substitution of one smell for another smell. It is one thing to kill germs in a test tube; to do this in a room with all its cracks and corners and its unavoidable leakage is a very different business.

The mortality per 1,000 living, at all ages, was 19.72.

#### CHELSEA.

Under the act of 1890, which was accepted by the city council, three hundred and sixty-eight privies have been abolished this year, and the work will be continued the coming year, where, in the judgment of the Board, it is necessary.

Owing to the breaking out of small-pox in Boston it was thought best, as a precaution, to advertise free vaccination, which began the twentieth of December.

#### CONCORD.

It was thought best by the Board, after careful consideration, to stop all direct drainage into the river in this town.

Regulations were made by the Board relative to school attendance in time of prevalence of infectious diseases.

There have been two cases of glanders in this town the past year. In both of these cases the horses have been killed as soon as a positive diagnosis was given by the attending veterinary.

We make the following recommendations, and hope the town will take action on the same:—

That a system of sewage disposal of some kind other than the present be put in at once.

That some suitable piece of land be bought by the town to be used by the inhabitants of this town as a dump. Some place should be procured

far enough away from the centre of the town, off from the main roads, to which every one should cart his rubbish, ashes, tin cans, etc. No garbage of any kind should be allowed to be dumped there, and the place should be burned over once or twice a year. The places now used are unsightly, if not dangerous to public health.

That the board of health of this town consist of three members, one of whom to be elected annually, to serve three years, to be separate and distinct from the selectmen.

#### COTTAGE CITY.

During last August our attention was called to the condition of the waters of Lake Anthony. On investigation we found the opening through the beach to the sea nearly closed, and the water becoming stagnant had allowed the sea-grass and moss to grow in large quantity. Although not unhealthy, it has an unpleasant odor, and renders unsightly what is otherwise a beautiful sheet of water. We recommend the appropriation of a sum not exceeding one hundred dollars for the purpose of cleaning the shore of the lake and maintaining a sufficient opening to the sea.

To conform to the requirements of chapter 195 of the Acts and Resolves of the year 1892 we appointed an inspector of provisions and of animals intended for slaughter or kept for the production of milk.

#### DEDHAM.

There has been a great increase in the scarlet fever cases over previous years. Considerable care has been taken by the Board to prevent the spread of this disease, and the scattered and wide range of the cases rendered it practically impossible for the Board to anticipate results. Many of the cases were traced by the attending physician to outside sources, and beyond the control of the Board. It has been found almost impossible, in some cases, to make the parents understand the value of implicitly following the instructions given by the attending physician, and in one case it became necessary to enforce directions by means of an officer. The three deaths were all in one family where the cases were severest.

The reporting of the cases of measles has heretofore not been insisted upon. The value of such a report is chiefly for the use of the superintendent of schools in relation to attendance of pupils afflicted or exposed to this disease.

A large proportion of the complaints made to the Board during the previous year were from the keeping of swine in the more thickly-settled portion of the village. It was found difficult to allow the keeping of swine in certain localities without their being a nuisance. In consequence the Board adopted the regulations now in force, prohibiting the keeping of swine within the more settled portions of the village, with the result that the complaints and nuisances from this source ceased. Under the present

idea that swine must be kept in filth and mire the Board believes that the prohibition of their keeping in the closely-settled portions of the town is the only method whereby this nuisance can be disposed of satisfactorily.

The town must, at a very early date, take the question of sewerage seriously under consideration. Each year the demand grows more imperative. It needs but the inspection of a majority of cess-pools in this town to convince one of the necessity of a more sanitary and efficient method. The cost of caring for these unsightly and unsanitary receptacles is as great, if not greater, than would be the expense to the town of an efficient sewerage system. Many cess-pools are becoming choked up, and are merely cisterns to be cleaned out often at great expense and discomfort, or else allowed to overflow as a continual menace to health. It is earnestly hoped that the town will take immediate action in relation to the sewerage question.

In accordance with chapter 477 of the Acts of 1893 the Board has prepared a set of by-laws for the consideration of the town in relation to the regulation of plumbing and plumbers.

A matter of considerable importance has been brought before the Board this year in relation to the better drainage of Wigwam meadows and Little Wigwam swamp. This subject has been before the town for many years, and has been reported on by previous boards of health and committees. While such reports have been unanimously in favor of improving this drainage, little has been done in this direction except to clear a ditch from Wigwam pond to the river. After a hearing and careful examination of the locality in company with some of the petitioners the Board decided that a careful survey and thorough examination of the swamps and facilities for better drainage should be made as a guide for a proper consideration of the subject. In accordance with this, plans and a report with estimates have been prepared which treat the whole matter in an exhaustive and thorough manner. This report is annexed to the report of the Board.

#### EAST BRIDGEWATER.

The Board has visited several scarlet fever cases this year, and has seen to it that no persons passed in and out of the houses where such cases existed, except those who were absolutely obliged to do so. We have, also, visited several horses, and have condemned one as affected with glanders and ordered him disposed of. We have also examined and quarantined several tuberculous cattle, and shall see that they are also properly disposed of before their milk and flesh have infected healthy human beings. The Board has also corrected several extreme nuisances.

#### EASTHAMPTON.

There have been comparatively few complaints of the existence of nuisances as compared with former years. People generally evince a readi-

ness to comply with the requirements of the Board, and seem to more generally realize that it is for their own benefit to keep their premises in a neat and cleanly manner.

With the contemplated and partially constructed sewer system and the introduction of an abundance of pure water into more general use we are confident that the appearance of contagious diseases will be greatly lessened.

#### EVERETT.

The city has been remarkably free from summer diseases of children. There was an increase in the number of cases of some of the zymotic diseases. Cards have been put on the houses wherever there was a case of diphtheria or scarlet fever, and notice sent to the school committee, public library and State Board of Health.

Everett is a city of new houses. It will be a matter of a great deal of public importance to learn how many persons become sick with consumption while living in these new dwellings, or, in case of death from that disease, to learn if the person was afflicted before coming here. The Board has taken steps to obtain, as far as possible, and record these facts.

The Board has fumigated houses after contagious diseases when requested to do so. As the disinfecting done by householders is, in most cases, worse than useless, since it is often thought that the burning of one or two ounces of sulphur has destroyed all germs and no further precautions are necessary, the Board voted that, beginning with Jan. 1, 1894, all houses where contagious diseases had occurred should be disinfected by, or under, the personal direction of the Board or its agent.

#### FALL RIVER.

It is especially gratifying to note that the exceptional decrease in typhoid fever cases observed in the returns for the year 1892 has been maintained during the year 1893. The sanitary education of our citizens is undoubtedly making great improvement. The limitation of the spread of contagious diseases has been helped very much by the fact that early in the year this Board adopted the system of immediately placarding every house in which a case of scarlet fever or diphtheria was reported to exist, and ordering that the cards remain in place until two weeks after the recovery, removal or death of such patient or patients. We would recommend that, even though we have no reason to be apprehensive of a cholera visitation, a house-to-house inspection every spring would result in a benefit to the public health, fully justifying the necessary outlay. It is our opinion that provision should at once be made for an annual visitation of this kind. We know that such a yearly stirring up and cleaning of the city is absolutely necessary. Experience has taught us that it is only by such system-

atic inspections, the sources of all nuisances can be successfully located and the city kept in a thorough sanitary condition.

|                                                                                         |       |
|-----------------------------------------------------------------------------------------|-------|
| Number of live cattle examined, . . . . .                                               | 1,325 |
| Number of live cattle examined and reported as unfit for food or food supply, . . . . . | 6     |
| Number of meat carcasses examined, . . . . .                                            | 26    |
| Number of meat carcasses examined and destroyed, . . . . .                              | 15    |

The following is a summary of the work accomplished in the office of the Inspector of Plumbing during the year just ended : —

|                                      |       |
|--------------------------------------|-------|
| Number of plans filed, . . . . .     | 471   |
| Number of new houses, . . . . .      | 268   |
| Number of reconstructions, . . . . . | 203   |
| Number of approvals, . . . . .       | 425   |
| Number of inspections, . . . . .     | 1,899 |

#### FITCHBURG.

During the past year the city has been visited with one of the most extensive epidemics of measles in its history, there being 592 cases reported to the Board. The disease was not of a severe form, and the number reported did not express the total number of cases. It began in January and rapidly increased until May, when 270 cases were reported. It as rapidly declined during the summer, and in August only one case was reported.

In regard to diphtheria the number of cases was ten, and was below the average for the past four years, during which time the records have been carefully kept, the average being 14.5 for the period. The cases showed a milder form than usual, there being only three deaths, one of which was called croup. The largest number of cases occurred in the first three months of the year, conforming to the average for four years.

There were twenty-eight cases of scarlet fever reported, as compared with fifty-one for 1892, and an average of sixty cases for the four-year period. The cases were unusually light, no deaths from the disease being recorded. The largest number of cases reported was in June. This does not conform to the average for four years, during which time the largest number of cases have been reported during the first months of the year, February showing the largest number of any single month.

During the year just past there have been twenty-three cases of typhoid fever reported, the largest number for four years, and six more than in 1892, when seventeen cases were reported. There were four deaths reported as compared with none for 1892. The largest number of cases occurred in September. A comparison of the records for the four years

past shows but few cases occurring during the first six months of the year, July, September, October and November showing the largest number.

The house-offal teams have been continued in the work of collecting swill as in the previous four years, doing good work in promoting cleanliness of the city. During the past year 363 cords of house offal have been collected and carried to the place of deposit.

The rules relating to plumbing have been carefully revised to keep pace with the science of plumbing and house drainage. The result of the work of the Board for the past year shows a vast improvement in the quality of plumbing work, and still better results are hoped for the coming year.

|                                                  |     |
|--------------------------------------------------|-----|
| Complaints received, . . . . .                   | 272 |
| Privy vaults discontinued, . . . . .             | 114 |
| Plumbing jobs inspected, . . . . .               | 362 |
| New water-closets inspected, . . . . .           | 513 |
| Houses fumigated or instruction given, . . . . . | 181 |

#### FRAMINGHAM.

Fifty-five complaints of existing nuisances have been made to the Board during the past year, all of which have been attended to and abated as far as was thought best. The owners of fifty-three tenements have been ordered to connect them with the public sewer.

#### GARDNER.

Realizing the great importance of milk as an article of food, early during the past season we requested the co-operation of some of our neighboring towns in a closer inspection of the milk that was being delivered in this town; failing in this, we would recommend that no person be granted a license to sell milk in Gardner unless such person furnish an acceptable certificate of cattle inspection.

The work of the cattle inspectors during the year has added much toward the improvement of the milk. They examined thirty-three herds, three herds more than last year. Some cows were examined five times. The inspectors condemned and caused to be killed eight cows, and condemned four carcasses. At the present time all the cows in town are considered in very good condition.

We would earnestly recommend to every family who depend on wells for their supply, or for the supply of their cattle, to use the greatest possible care of their wells, and avoid all possible contamination from cesspools, water-closets and barns, or other filthy matter. By doing so they will in a great measure protect themselves from typhoid fever.

We have to report quite an extensive epidemic of typhoid fever, but rather mild in its character, and fortunately resulting in only one death. We believe that had the Board known earlier the existing circumstances this epidemic might have been somewhat lessened. As soon as the Board

investigated and found the source of infection the epidemic was confined to a very small radius, and soon brought under control. It resulted from impure milk occasioned by impure water.

#### GLOUCESTER.

One hundred and ninety-three nuisances received attention. All *bona fide* nuisances have been abated where possible, but in a city without sewerage it is occasionally advisable to be very lenient, especially where some neighboring quarrel seems to have been the animus of the complaint, which sometimes appears to be the case.

If sewerage is not soon adopted the city must resort to some method less objectionable than the present method of disposing of night-soil and sink-waste.

#### GREAT BARRINGTON.

During the year the selectmen, acting as a board of health, have been notified of twenty-seven cases of scarlet-fever, of which but one proved fatal; and four cases of diphtheria, of which number two cases proved fatal. The board adopted the usual sanitary measures of precaution in such cases. We believe that the cause of many of these cases exists in the carelessness on the part of individual families in the disposal of garbage and neglect to keep the dwellings properly cleaned. Dirt and refuse matter are two great enemies to public health, and we cannot urge too strongly the importance of an observation of the utmost care in these measures.

#### GREENFIELD.

The Board feels that the most important matter they have to recommend to the careful consideration of the town is the subject of sewers. This is a very broad subject and difficult and impossible for us to treat in the thorough manner that it demands. Our present system, if system it can be called, is totally inadequate for the needs of our growing town; many sections are entirely unprovided for, and many other sections where there already is a public sewer, suffer great expense and inconvenience at the time of a heavy rainfall, owing to the inability of the tile to carry off the large amount of surface water that is thrown into it, and in consequence cellars are flooded. This difficulty is experienced more or less throughout the whole town and sooner or later the surface water will have to be taken care of in some other way.

#### HAVERHILL.

The appointment of an inspector of plumbing has been a great relief to the agent, and great public good will be the outcome, for, as we have already stated in previous reports, it is found impossible for the agent, in addition to his other duties, to give this branch of the sanitary service, so extremely important, the attention and careful supervision that it should have. Plumbers are now required to test their work by water pressure in



the presence of the inspector, which gives a much more thorough and satisfactory inspection. The record shows that three hundred jobs of plumbing (new and remodelled) have been inspected last year.

*Nuisances Investigated During the Year.*

|                                                            |       |
|------------------------------------------------------------|-------|
| Garbage collected, loads, . . . . .                        | 1,320 |
| House sewerage defective, . . . . .                        | 42    |
| Plumbing defective, . . . . .                              | 30    |
| Privy-vaults full and offensive, . . . . .                 | 138   |
| Privy-vaults cleaned, . . . . .                            | 300   |
| Privy-vaults removed, . . . . .                            | 142   |
| Whole number of privy-vaults removed since 1888, . . . . . | 1,002 |

The general health of the city during the year has been excellent. No fatal epidemic has visited the city.

The faithfulness and care with which contagious diseases are reported by physicians speak well for the interest in their profession and in the public welfare. Notwithstanding the wide publicity that has been given to the law that requires householders as well as physicians to report dangerous contagious diseases to the Board of Health, some cases occur where the disease is so mild that the children are hardly considered ill enough to be put to bed, and consequently no physician is called and no report comes to the Board. Thus no efforts are made to prevent its spread, and great damage is liable to be done in consequence by spreading the disease in the neighborhood in a malignant form.

HINGHAM.

Early in August, complaints having reached the Board regarding a tallow factory at Fort Hill, representatives of the Board visited the establishment, which they found in a filthy condition.

The business seemed necessarily to give rise to offensive odors, and although the health of the community should always be paramount to the pecuniary interest of any individual or firm, at the earnest request of the proprietor a further time was granted on the plea that the business had but recently been established and the firm had been unable to put their manufactory into proper shape. The claim was also made by the proprietors that they, by undergoing a larger expense, could use apparatus by which all offensive odors would be destroyed. They promised to introduce such machinery at once, and an opportunity was given them to make such changes.

The establishment was several times visited by members of the Board, to watch the results of any changes made by the proprietors. On September 22, no better results having been obtained, the business was declared a nuisance by this Board, and they were ordered to close their works at once, which order was promptly obeyed.

## HOLYOKE.

The past year throughout the city has been fairly healthy. None of the contagious diseases have prevailed at any time to an alarming extent. Although there were numerous cases of diphtheria and scarlet fever during the first four months of the municipal year just ended the number of cases during the rest of the year and at present is much below the average.

Small-pox again appeared in our midst during the month of September. Although limited to a single block, it attacked three persons, all of whom recovered after a more or less protracted stay at the pest-house. Here again the city physician desires to call your attention to, and to emphasize a recommendation of the Board of Health, viz., that there be a general vaccination. The Board of Health calls your attention to a deficiency in the heating apparatus at the pest-house. That such a deficiency exists was only too apparent during the stay of the recent cases, and, added to this, was a failure in the water supply. The water at the pest-house, obtained from a well sunk beneath the kitchen, has always been of a very poor quality, but this year it became so impure it had to be discarded even for washing purposes.

We have been remarkably free from typhoid fever during the entire year.

The Board this year as heretofore recommends that all the alleys be graded, and that those between our principal business streets, through which heavy truck-teams pass, be paved with stone, brick or any other material which seems proper.

## HUDSON.

The greatly increased number of calls to look after nuisances caused by the disposal of waste water, has convinced the Board that the time has come when the town ought to take initial action with regard to a system of sewerage. When all the water used by consumers is pumped or drawn from wells, the quantity used may be easily disposed of in cesspools, and taken care of by the surrounding earth without danger of infection, if the cesspools are emptied and cleaned periodically. Or, if the waste water is discharged into natural waterways, it may cause no nuisance in a sparsely settled locality, or if there are only a few discharge pipes. But, when an abundant supply is furnished by the town water-works, and its use is almost universal, the quantity used is so much increased, that it is only a question of time when the earth about cesspools will become saturated with water, and entirely filled with decomposing filth. And this condition will be found, not only on one man's premises, but in entire neighborhoods, growing worse constantly as they become more thickly settled.

The Board would recommend the voters to take action by appointing a committee to consider the question of a sewerage system, with authority to

consult the State Board of Health and obtain their advice and instructions, and with authority to employ a competent civil engineer to make surveys, plans and estimates for a complete system of sewerage, and take any action necessary to make a full report to the town on the subject at some subsequent meeting.

#### IPSWICH.

In regard to the sanitary condition of the town, the people, generally, have complied with the requirements of the Board, and in no case where we have ordered a nuisance abated have we had any trouble or had to resort to legal measures.

In regard to contagious diseases amongst the cattle in the town we will state the following: the selectmen appointed a cattle inspector, and the Board of Health also appointed him as their agent giving him full power to act for them, and he has faithfully attended to his duties. The whole number of cattle inspected by him was eleven hundred and four, and he ordered nineteen of this number quarantined as, in his opinion, they were diseased, and notified this Board of his doings. The State Cattle Commissioners were at once notified in regard to same, who came and examined them and ordered the killing of eight which were sick with tuberculosis, and their carcasses were properly buried.

#### LAWRENCE.

Six hundred and seventy-four vaults have been abolished since Jan. 1, 1889. There have been 2,184 water-closets placed in buildings where vaults have been abolished.

During the year 19,714 loads of garbage have been removed, an increase of 4,376 over 1892. Realizing the necessity of a different method of disposing of the waste matter, the Board has recommended that some provision be made to dispose of this material in a satisfactory manner.

There has been an alarming prevalence of scarlet fever during the year, and the percentage of fatalities greater than formerly.

More cases of measles have been reported than ever before, forty-six cases coming in during one week. The fatalities have been small, only three out of sixty cases resulting fatally. Diphtheria has not been very prevalent. During the December vacation, 3,200 school children were vaccinated by the ward physicians. We were pleased at the ready response from the agents of the corporations as we found that vaccination was being carried on in a very systematic manner.

We have had five cases of glanders in horses and seven cases of tuberculosis in cattle, which were pronounced such by the Cattle Commissioners.

#### LEXINGTON.

The Board has made several official tours of inspection; among them *was* the inspection of the several hotels and private boarding-houses, and

we are pleased to state that, with few exceptions, the sanitary conditions were good. The inspection of some of the numerous newly built houses was not so assuring; indeed, the systems of house drainage in many of them were alarming. One case, for instance, may be cited: a double tenement; no water supply except from well dangerously near drain; untrapped sinks discharging into an open tank in cellar, contents of which were used to flush closet; without vent; useless trap; cesspool twenty-eight feet from house. It would almost seem that the ingenuity here displayed tended only toward one result, — the death of the occupants.

Some years ago the question of a sewerage system for the town was agitated to the extent of the appointment of a committee, the investigation of different schemes was initiated, and even the engineer's survey obtained. This subject, so vital to the interests of the town, seems to have passed into oblivion; nothing is heard of it except now and then a few desultory remarks on the matter. It is hoped that this subject is not entirely forgotten, for if forgotten and neglected there will be a rude awakening, perhaps within a few years.

#### LOWELL.

During the year 1893, twenty-five thousand five hundred and thirty-seven (25,537) loads of ashes were removed from houses and stores to the various dumping-grounds.

Late in the year 1892, the Engle cremator was completed so that for the year covered by this report it has been in use, destroying about one-half of the garbage of the city. Owing to the usual friction that all new undertakings have to overcome, it was not until April that a complete system of account was commenced. Since April every pound of swill consumed and every pound of coal used has been weighed daily so that, estimating the amount burned the first three months of the year and adding to it the amount weighed for the last nine months, we have, say 3,500 tons of swill consumed for the year 1893, beside the miscellaneous articles enumerated in the table printed herewith:—

Three thousand five hundred tons swill and market refuse burned.

Four horses.

Seventy cats.

Sixty-three dogs.

Two hundred and fifteen mattresses.

Four hens.

Seven rabbits.

One raccoon.

Three loads and one barrel infected clothing (small-pox).

Seven loads infected clothing (diphtheria).

Seventy-seven thousand one hundred and sixteen pounds paper burned on ground in rear of cremator.

The opinion of the Board, after the experience of the year with the Engle cremator is briefly this: Under no circumstances would it be willing to return to the old method of swill-house distribution to farmers, and it is also convinced that cremation of the garbage is more satisfactory to the inhabitants of a city than the rendering process. The cost of burning garbage at Engle cremator, from Jan. 1, 1893 to Dec. 31, 1893, was \$7,670.77.

The Board caused a thorough inspection of the water-shed of River Meadow brook to be made, and the results are such as to demand prompt remedial and preventive action.

The work of inspecting the tenement houses of Lowell in a thorough and systematic way has been commenced this year, and so far the results have been very satisfactory; but the great value of the inspection will come in later years, as from the records made and kept by the library system, an inspector can turn to them at any time and find the condition of any house in the city so far as relates to plumbing, drainage and ventilation, and will then only have to keep watch that the premises are kept clean and in repair.

From June 27 to September 16, there were 14,918 baths taken by men and boys, a decrease from 1892 of 8,347, but it is explained by the fact that more than that number used the house to put their clothes in, and then came outside and swam in the river.

#### LYNN.

The Board of Health appointed an inspector of plumbing under the provisions of chapter 477, Acts of 1893.

Under the provisions of a special act of May 4, 1893, chapter 313 (1893), the Board of Health of Lynn was authorized to appoint an "inspector of provisions, and of animals intended for slaughter or kept for the production of milk, who should also be an inspector of milk, butter, cheese and vinegar."

Each of the officials appointed under these acts contributes a full report of his transactions.

The Board recommends the following amendments to the milk laws:—

1. That the cost of analysis be charged as court costs.
2. That boards of health be vested with power to revoke licenses.

The failure of the city government to carry out our recommendations or to adopt a system for the disposal of garbage and night-soil placed the Board in the predicament, on April 20, of having no place to dump that material, or otherwise dispose of the same by cremation or extraction. To relieve the situation the city purchased the land about the outfall sewer, and we entered into contract with an excavating company and had a temporary basin dredged for the scow on land alongside the outfall sewer at West Lynn. A dock was also constructed with a small, frame building thereon. The disposition of offal by loading it into the scow, towing it

twelve miles out to sea and there dumping it in deep water, was inaugurated, and has proven a success.

Twelve trips have been made and 1,486 tons of offal so disposed of, without accident or a single complaint, at a cost of ninety-four cents per ton for labor, towage and expense of repairs. We shall pursue this method until the city council adopts some other and better one. We recommend the immediate purchase of another scow. The dump at West Lynn was abandoned on the expiration of the lease, April 20, and no garbage was placed thereon after that date.

The Board requested that immediate steps be taken by the city council to provide suitable accommodations for persons affected with contagious diseases.

#### MARBLEHEAD.

The health cart is one of the most important institutions in our town, and we hope has come to stay both summer and winter. Two thousand loads of refuse matter have been collected the past year. To find persons who will look after this refuse and see that it is properly covered has caused the Board considerable trouble. We suggest that the town set aside a place to be used as a dump in case there were no individuals who cared to take it.

We suggest that our town should employ a health officer to investigate nuisances, post notices, inspect meat, milk and water, attend to the fumigating of all places where infection exists, and who would be in many ways of great service and value.

#### MARLBOROUGH.

In parts of our city where the health of our citizens was in danger, and along the banks of brooks, during the past two years, this Board through its agent has enforced connections with the public sewer under the powers granted in the Public Statutes, chapter 132 of the Acts of 1890. The agent of the Board reports that two hundred and sixty-seven buildings have been plumbed; one hundred and fifty-one cases where alterations or additions have been made in the plumbing; making a total of four hundred and eighteen inspected and approved by him. It is evident from the number of inspections made that the people are mindful of the economic and sanitary advantages of the public sewer. The enforcement of our regulations governing plumbing worked to the advantage of all.

Many nuisances that have been a bugbear to every Board of Health for years past have disappeared entirely since the house drainage in these localities has been conducted to the sewer. Cards calling attention to the regulation restraining persons from making the vacant land of the city a nuisance, were posted wherever there seemed to be a cause of complaint.

In August a case of rabies appeared in town. A dog with a disease of doubtful diagnosis was killed by the police. The mayor with a representa-

tive of the Board of Health agreed to request Dr. Ernst of the Harvard Medical School to decide by inoculation experiment whether the disease of the supposed mad dog was actually hydrophobia. The result of the experiments proved that the dog was afflicted with the genuine disease, and proved the wisdom of muzzling all the city dogs. No more cases appeared though several dogs were said to have been bitten by the diseased dog.

#### MAYNARD.

The Board has encountered a greater obstacle in trying to educate a certain class of people to understand that it is necessary to flag a house where there is scarlet fever and cause the flag to remain displayed for a proper and legal length of time. They also have seemed to think they were doing the Board a great favor by allowing the flag to be attached to the house at all, and as soon as the case is able to sit up, "although then probably in the most contagious stage," display more or less disposition to resent the idea that it is then highly necessary that the quarantine should remain longer. This condition can only be overcome by education.

#### MEDFORD.

Sixty-one nuisances have been reported to this Board during the year. All have been carefully investigated and abated.

In each case of diphtheria, measles, scarlet fever and typhoid fever, the clerk has notified the school committee and librarian of the public library.

The work on our local sewage system should be pushed to completion as rapidly as possible, so that we may be rid of that increasing and menacing danger, the saturation of the ground with sewage. Since the collection of ashes, swill and garbage has been under the direct care of the city, and the contract system abolished, the work has been done in a thorough, cleanly and efficient manner, and the results are highly satisfactory to this Board. With the same arguments we have used in the past, in favor of the collection by the city of ashes and swill, we would now earnestly recommend that night-soil be collected in the same manner.

#### MELROSE.

More than one hundred and fifty nuisances and complaints have received attention from the Board. The sources of nuisance or complaint have most frequently been neglected cesspools and offensive privies, but also imperfect traps, or total absence of them, and defective sink drains.

The former method of return to school by children recently recovered from contagious diseases, has been by permits given by the Board, based upon the attending physician's certificate of recovery. But that method having often proved troublesome to parents, a more direct plan is now employed, of permits, based as above, but issued by the chief of police, as

The subject of maintaining bath-houses all the year round was the subject of a special recommendation by His Honor the mayor in his inaugural address to the city council, and a special commission has since been appointed by him to consider the subject, and make such recommendations with a view to establishing such accommodations as may be deemed expedient. The supplying of public bathing facilities during the winter as well as during the summer months has the cordial approval of the board of health, as being in the line of promoting the public health.

#### *Examination of Plumbers.*

The examining board held 44 meetings and examined 258 candidates for plumbers' licenses; 93 were for master plumbers' licenses, and 50, or 52 per cent., passed the examination and were licensed; 165 were examined for journeymen plumbers' licenses, and 106, or 64 per cent., passed the oral examination and were notified to report at the shop for a practical test. Of the 106 candidates who passed the oral examinations, 77 passed successful examinations in the shop and were given licenses.

#### *Lying-in Hospitals.*

During the year 423 confinements have taken place in the licensed hospitals, and no deaths have been reported.

#### *Stables.*

There were 248 applications, and 198 were granted.

#### *Prosecutions.*

During the year there have been 30 prosecutions for violations of various health laws. In these cases there were 25 convictions, 2 acquittals, 2 were *nol-prossed* and 1 is still pending.

Of the convictions, perhaps the most important was that of a physician for failing to report a case of contagious disease which he had been called to attend. In this case a fine of fifty dollars was imposed in the lower court, and, after an appeal and trial before a jury, the judgment of the lower court was affirmed, and the fine increased to one hundred dollars.

The physicians of the board examined 39 cases reported as small-pox, none of which proved to be such.

The bodies of 454 persons dying without a physician were also examined, to determine the causes of death.

#### *Animals killed at Abattoir.*

|                   |        |
|-------------------|--------|
| Cattle, . . . . . | 25,814 |
| Calves, . . . . . | 14,141 |
| Sheep, . . . . .  | 77,906 |
| Swine, . . . . .  | 470    |



The cases of scarlet fever were also widely separated as to families affected, and there has not been a general epidemic, all the cases having occurred in but six different houses.

The occurrence of five cases of typhoid fever on one street and within a short radius would seem to imply some local contamination, but no obtainable evidence could satisfactorily explain the origin of the disease. Chemical examination of well waters furnished little light, but since the disease is generally believed to be of bacterial origin, it might well happen that a chemical analysis would give entirely negative results. The milk supply theory did not apply, since there was not a common supply in the different affected families, nor was any disease known on the premises from which the several supplies came. Without attempting to show any connection between the facts, it may be stated that fourteen of the cases were comparatively near the river, eight of them being very near. A very extensive epidemic of measles occurred in the autumn.

It is well for people everywhere to know that it is now believed by the highest medical authorities that consumption is to a very considerable degree communicable from person to person, and that the germs abound in matter expectorated in coughing; that constant care should be taken to disinfect and destroy such discharges, and especially that the common habit of promiscuous spitting should be avoided. Matters so scattered, by drying, become converted into dust, and, in this form, are widely scattered to be inhaled by others, and since the germs are extremely tenacious of life, the seeds of the dire disease are widely sown.

It cannot be doubted that such precautions as are above described would, if generally adopted everywhere, have a marked effect in diminishing the frequency of consumption.

During the year two cases of glanders in horses have been reported to the Board by the inspector of cattle. Both animals were subsequently condemned by the State Cattle Commissioners and killed by their order.

#### NANTUCKET.

The Board made investigation of many nuisances reported, and believes that the town has been kept in an improved sanitary condition in consequence of a general interest manifested by all good citizens, to live up to the best ideal of proper sanitary safeguards. As a result of such care and attention, no contagious disease of any kind has been reported to the Board during the year as originating at Nantucket.

#### NEEDHAM.

The health of our town and its freedom from any serious epidemic of infectious and contagious disease (except that of typhoid fever) during the past year is a matter of sincere congratulation.

What will soon be required as the town progresses, to put us in a

thorough sanitary condition, will be a general system of sewerage, which the introduction of a public water supply generally demands.

Your health officer has made one hundred visits of inspection and examination, visiting sixty places where complaints have been made. Fewer petty complaints have been made than in previous years.

Fewer swine have been kept in the thickly settled portions of the town than in former years. Some piggeries have been entirely abandoned. In a few cases, as a last resort, the Board appealed to the court to enforce its orders.

#### NEW BEDFORD.

The Board acting under authority of Public Statute, chapter 80, section 24, vacated houses on Turner's court known as Holy Acre. This act the Board regards as one of the most important taken during the year. The statute places the entire responsibility on the Board. The houses in question were so low that it was impossible to drain them, and it seems unfortunate that there are no means of preventing building or moving houses already built to such locations. In every growing city, building is continually outgrowing the drainage system. But for such buildings drainage can be supplied before they are occupied. The policy of the Board has been and will be to vacate all such tenements at the first sign they give of danger to the public health. The Board would recommend that action be taken on the proposed building rule establishing the height of cellar floors above high water. The nuisance caused by privies is being rapidly abated, when such a nuisance occurs on the line of a sewer.

All garbage is ploughed in daily, and when about one acre is covered a quickly growing crop is planted, and in a surprisingly short time, on digging down, no garbage can be found. Thus the essential condition for rapid decomposition in the earth is attained, namely, superficial burial. The objection to superficial burial is that the burial products may more readily become exposed and so cause nuisance, or, by drying, blow about, and under proper conditions cause disease. This objection is met by the facts that the material buried is not of such a character as frequently contains disease germs, and the moist and heavy condition of the soil is such that it is seldom dry except upon the surface. The farm is remote from any source of water supply. So far the method is satisfactory in all respects. The material is thus utilized as a fertilizer, which is its only value, as the cost of extracting the fat, the only constituent of value, would more than counterbalance the estimated return.

The Board voted to inspect the sanitary condition in respect to drainage of the various school houses in the city. All, with the exception of one, were found in good condition. The school committee were notified of the condition of this school.

|                                             |           |       |
|---------------------------------------------|-----------|-------|
| Number of inspections made during the year, | . . . . . | 2,384 |
| Number of plumbing inspections made, .      | . . . . . | 1,650 |

The Board investigated an epidemic of typhoid fever which occurred in the last half of the year, embracing 201 cases in all. No satisfactory conclusions were reached which would account for the epidemic as a whole, though suspicion pointed strongly to the existence of infection upon a small island in the harbor which many of the persons attacked had visited during the period of epidemic.

The Board amended its quarantine regulations and publishes them in full in its report.

#### NEWBURYPORT.

There has been a great falling off of cases of diphtheria and scarlet fever from the previous year, but a large increase of cases of typhoid fever.

Rules and regulations relating to plumbing were adopted by the Board.

#### NEWTON.

The general health of the city has been good, and barring slight outbreaks of diphtheria in the early spring and fall, and an epidemic of measles in the early summer, would have been deemed excellent.

The contagious wards at the hospital have been found very useful during the year; the early removal of patients to them having greatly aided the Board in preventing the spread of disease. The wards have been in almost continuous use during the year, sixty-two cases having been admitted. The cases were divided as follows,—scarlet fever, fifteen; diphtheria, twenty-eight; measles, nineteen.

The Board authorized free vaccination to all comers in the several villages.

#### NORTH ANDOVER.

As a matter relating to public health, we think the attention of consumers of milk should be called to the fact that most of the herds supplying milk in this town are not allowed any exercise at all, but are tied up by the neck from November till May in badly ventilated barns, and never turned out of doors.

We recommend the purchase of one of the odorless pumps, and that its use be made compulsory in the village whenever vaults or cesspools are cleaned during the day.

We find occasionally a person who is willing to allow his vault to overflow his neighbor's land. Such need the stimulating effect of the sharp end of the law.

#### NORTH ATTLEBOROUGH.

The failure of people to submit to the guidance of any fixed rules for observance in trying to prevent the spread of any infectious disease is often due to thoughtlessness rather than to a desire to thwart the beneficial effects of such rules. It often requires the experience of an epidemic to

teach the public that there are certain rules and regulations which must be strictly observed.

There has been a marked decrease in the number of cases of diseases of a contagious character reported during the past year.

#### ORANGE.

With the opening of the season the Board recognized the need of removal of "waste, filth and house dirt," and engaged a scavenger who gave two days each week to the collection of rubbish and garbage on the principal streets of the village during the heated season, with the result that never before in the history of Orange was the town in as sanitary a condition.

The Board has investigated one hundred sources of filth and offence. The members, individually, have investigated many others.

The Board of Health would urgently request parents to investigate the subject of "vaccination" thoroughly, that they may intelligently act regarding it.

The bodies of five dead animals have been buried by the Board. Animals infected with tuberculosis have been condemned. Herds have been inspected by the Board's agent. Horses with infectious diseases have been cared for, and dogs killed.

#### PITTSFIELD.

The sewage system, now almost completed, has furnished a long-needed want, and the amount of good obtained by the same is immeasurable.

During the year 1893 the new ordinance for plumbing necessitated the licensing of plumbers and drain-layers.

|                                                          |     |
|----------------------------------------------------------|-----|
| Number of licenses granted to plumbers, . . . . .        | 8   |
| " of licenses granted to drain-layers, . . . . .         | 13  |
| " of plans of plumbing submitted for approval, . . . . . | 253 |
| " approved, . . . . .                                    | 218 |
| " rejected, . . . . .                                    | 35  |

During the past year the Board of Health has been called on to investigate four outbreaks of tuberculosis at different farms. At one farm the Board considered about thirty per cent. of the cows affected. So far, twenty-one of them have been slaughtered, and of these nineteen have been found diseased, while two were found not diseased. At another farm over fifty per cent. were considered unsound. Up to date thirteen have been slaughtered, and every one has been found diseased. At another farm two cows have been slaughtered, both of which were affected. The Board considers that the chief cause of its spreading among dairy cows is overcrowding, deficient cubic air space and defective ventilation. The Board also considers a more thorough State system for regulating and managing the disease should be inaugurated.

## PLYMOUTH.

Sixty-three places have been examined and nuisances abated without having received any formal complaint.

Nearly all of the cases of scarlet fever, typhoid fever and diphtheria have been traced by the Board to imperfect drainage and ventilation.

After learning the facts in the cases the Board issued orders to those families from which cases were reported, and had them enforced; and the Board felt that after the last case was reported well, and the places had been disinfected, that there would be no danger from these sources. During this time circulars were distributed by the Board throughout the town giving instructions what to do in case of diphtheria.

In accordance with the Acts of 1893, chapter 477, the Board has appointed inspectors of plumbing, and, at the request of the selectmen, prepared a list of by-laws, and presented them to the town for adoption.

## QUINCY.

Your Board strongly recommends that plumbing regulations or ordinances be enacted by the council as a matter of safety to the public health. The inspector is powerless without them in many cases. The brooks have been thoroughly cleaned under the direction of the inspector, and the Board has every reason to believe that the work has been economically, thoroughly and conscientiously done. The physicians are negligent in their duty of reporting contagious diseases, and until they are brought up to the law the same state of affairs will exist.

Number of nuisances discovered, 306; number abated, 298.

## READING.

There have been twenty-one nuisances investigated, and all cases except two have been abated by owner or occupant. One of these was abated by the Board, and the owner paid the bill. The other one will be attended to before the premises are occupied.

## REVERE.

The town has been favored with a freedom from contagion to an extent to be a matter of satisfaction to the citizens within the last twelve months. Scarlet fever showed itself the latter part of the year. The prompt and stringent requirements of the Board have done much to prevent it being spread over the town.

## ROCKLAND.

We have had one case of glanders reported during the year, and the Cattle Commissioners ordered the horse killed, which was done.

One of the vital questions for the people of this town is that of sewage. While in our present financial condition, any general system for the town

to adopt would be too expensive, yet there is a very simple and effective way of disposing of sewage that could be adopted by individual families. The plan is to have the sewage pass through an underground drain with branches in all directions, the drains to be constructed of broken drain-pipe, stones or anything that will allow the sewage to pass into the ground at short intervals.

#### SALEM.

In the month of February a sharp outbreak of diphtheria occurred near the cotton mills. The type of the disease was very serious and vigorous measures were employed to combat it. Houses were guarded night and day by police officers, thus stopping one of the chief sources for spreading the disease. Everything possible was done for the sick and for the afflicted families.

Though some cases of scarlet fever were severe, only one proved fatal. The type has generally been mild. We note with satisfaction the marked decrease each year for the past three years in the number of cases of this dangerous malady.

The type of typhoid fever was severe and active search for the cause was made by this Board, milk being particularly looked after. Visits to each house were made, also to shops where milk was sold, and the milkmen, their farms, the cattle, the sources of water supply of the cattle. The fault could not be traced to the milk.

The work of collecting the ashes and rubbish the past two months has been done in a very satisfactory manner. Eight thousand one hundred and seventy-two loads have been collected. This is an increase of over 1,400 loads more than in 1892. These ashes have been used to fill up unsightly and often unhealthy places in our city.

#### SAUGUS.

The Board made personal investigation of a number of reported nuisances, and on their tour found much work to be done in regard to neglected privies and vaults. These cases were reported to the owners, and in the majority of cases were looked after in a satisfactory manner. Our inspector also found many places where sinks were not secured by traps, which allows of all gases arising from contents of cesspools to flow back into the rooms occupied by the residents. This should not be allowed, and the Board has obliged owners to correct these troubles so far as its knowledge of them is concerned.

Perfect cleanliness of dwellings and surroundings is what will insure good health and is of the utmost importance, as by its strict observance the air is not polluted and germs of disease find no lurking places.

The Board publishes a very full and complete set of regulations including practical instructions relative to disinfection.

the lake by the construction of a dam across the opening, by which means the water was changed from salt to fresh. We succeeded by this means in destroying the grass, as evidenced by the large quantities which came ashore during high winds, and the accumulation thus coming ashore was raked up and carted away as soon as possible.

#### DANVERS.

There was an epidemic of measles during the spring and summer, probably many more cases than were reported, as the disease is often so mild that no physician is called to attend.

The cases of diphtheria were treated with the new remedy, diphtheria antitoxin, of which so much has been expected. We have thought it advisable to keep an antitoxin syringe and a supply of antitoxin on hand, so that any physician in town can obtain them of the board of health at short notice.

The time is not far distant when the town must adopt a general sewage system, which is the only satisfactory way of disposing of the sewage in thickly settled parts of the town.

#### DEDHAM.

The town is to be congratulated, both in being able to obtain so excellent a service as will be hers when the metropolitan sewer is completed, and also in having the prospect of obtaining so speedy a relief from the extremely unsanitary conditions now prevailing in her midst. Upon the completion of the trunk sewer the town must construct a system of lateral or branch sewers to connect therewith, and some provision must be made for this purpose in the near future.

The keeping of swine in the town and the teaming of swill and offal through the streets seem to be an annual source of difficulty and nuisance.

#### EVERETT.

In July it came to the knowledge of the board that there were some unreported cases of diphtheria. The attending physician was prosecuted and fined fifty dollars in the district court. In these cases the probable source of infection was an old lounge that had been brought from out of town and upon which a child had died with diphtheria. It was put out in the yard, and the children had used it. Very soon there were 7 cases and 1 death in the neighborhood. Possibly there were other mild cases that were not recognized. There has been a number of cases since in that locality. In a number of instances we are quite sure that the disease has been contracted from infected persons from out of town or by children visiting infected houses in other places. In one case a child was sent here because its brothers had the disease. This child remained well, but a child in the

## WAKEFIELD.

We have had no epidemic. The general complaints of nuisances have been few and soon abated, and the more important ones have caused us little trouble. Our formal meetings have been few, but all that were necessary, as the members of the Board met almost daily and the business was often informally discussed and disposed of. We have done nothing toward abating our permanent nuisances this year, as we have concurred with the opinion of past Boards that the expense of the attempted improvement would far outweigh the very doubtful benefit. There is but one way to rid the town of these unsavory and unsightly spots, and that is by a proper sewerage system.

During the session of 1893 the Massachusetts Legislature passed a law governing the business of plumbing in cities and towns in the State. In accordance with this law we appointed a local board of examiners of plumbers.

## WALTHAM.

A request by the Boston Manufacturing Company to remove some cases from corporation tenements compelled the Board to make provision for the treatment and care of scarlet fever patients, and, at first, quarters were engaged in the Newton Cottage Hospital; but the number of cases increased so rapidly that the Board deemed it more convenient and economical to procure a house somewhere in the city for temporary use as a contagious hospital. The result was that the house No. 255 South Street was taken for that purpose, and a house-keeper and a nurse were procured to take charge of cases carried there. This house was maintained as a hospital from March 14 to May 15 and proved ample to accommodate all cases of children sick with scarlet fever whom it was desirable to remove. On one occasion, a mother and child were furnished with board and room while the child was under treatment for the disease. We believe that the prompt removal of cases of scarlet fever to a contagious hospital, well equipped, and managed by the Board of Health, will greatly diminish the danger of the spread of this disease. So positive does the Board feel of this proposition that it thinks it may safely say that a contagious hospital would have prevented all but say twenty cases of the three hundred and eighty reported during the last two years.

Before the schools closed in June the disease was fully eradicated.

Since that time cases have only occasionally appeared. During the year, one hundred and thirty-two cases altogether have been reported, as against two hundred and fifty-four cases in 1892.

Diphtheria, of all diseases, is the most treacherous, deceiving even the experienced physician. One day apparently mild, the next it has its victim so firmly clutched by the throat that the most skilful treatment is of no avail. When once the deadly character of this disease is appreciated,



the public will insist upon the use of as radical measures to prevent its increase as are now employed to prevent the spread of small-pox, and we believe that such measures would go far to stamp it out. In Massachusetts, during the year 1892, there were two deaths from small-pox, while there were nine hundred and twenty-eight from diphtheria. In the whole United States, omitting North Dakota, it is reported that, in the same year, there were only one hundred and six deaths from small-pox. This shows that there were in 1892 only one-ninth as many deaths from small-pox in the United States as there were from diphtheria in the State of Massachusetts alone.

Several cases are detailed in the report, illustrating the value of isolation and removal to a hospital provided for contagious diseases. It is almost needless to say that no effectual isolation can be made in all instances without a contagious hospital to which patients may be promptly removed, and it is as a means by which to effect absolute isolation of these dangerous cases that the hospital now nearly finished will demonstrate its greatest value to the city.

We wish at this point to call attention to a matter which to many may appear trivial, but should not be overlooked by those seeking out the methods by which disease is propagated. Upon a visit of our Board to the public schools we found a custom prevailing in many of them of collecting the children's pencils at night and dealing them out promiscuously the next morning. We believe that this custom is a bad one; and we are pleased to say that, on our suggestion, the superintendent of schools caused a rule to be established that each scholar should have his own individual pencil.

It has long been known that, upon reopening the schools after a vacation, infectious diseases seem to take a fresh impetus, and, on the other hand, when the schools are closed, such diseases seem to relinquish their hold upon the community. We therefore believe that during the long summer vacation, the school houses should not only be cleaned in the usual manner, but also thoroughly fumigated and disinfected from top to bottom, and the basements thoroughly whitewashed.

A contagious hospital is now being built, consisting of two wings and a dwelling-house, all connected by long corridors, one wing being for scarlet fever cases and one for diphtheria cases, each capable of accommodating ten patients; and each is so constructed that it can at any time be enlarged at a comparatively small expense, should occasion require.

Under the plumbing act, as it stands, a board of examiners has been organized, consisting of the present chairman of the Board of Health, the present inspector of buildings, and a practical plumber who was chosen by the Board of Health as the third member.

The Board has adopted a system of registering plumbers who were in business at the time the act took effect, that is, on or before July 10, 1893.

To each plumber registering his name a certificate has been issued certifying that he was engaged in the business prior to that date. These certificates have proved of great practical convenience to the plumbers of the city who do work in other places by enabling them to readily prove the fact that they were engaged in business prior to July 10, 1893, and therefore entitled to pursue their calling without a license.

Altogether about 1,100 connections have been made with the public sewer. The total estimated number of connections made and to be made is 2,500.

#### WARE.

A careful investigation of the sanitary condition of the buildings and premises in town was made early in the year by agents, who were appointed for the purpose, and who were furnished with printed blanks containing various inquiries, upon which they recorded their answers. At a later time a second visitation was made by these inspectors where it seemed desirable to the Board that it should be done. In this way accurate and complete information was secured as to our sanitary condition.

In compliance with an act of the Legislature passed during the year, the Board prepared a set of by-laws in relation to plumbers and plumbing work, which were adopted by the town, and which are now operative. These by-laws require that those who newly enter the business of plumbing should pass an examination and obtain a license, which must be renewed each year that they continue in business. All plumbing work, except repairs of leaks, must be done only after proper notice given the Board of Health or its appointed agents, and must be approved by the Board after examination by an inspector of plumbing appointed for the purpose.

#### WELLESLEY.

No cases of typhoid fever have been reported to the Board during the year.

There have been several instances in which the advice of the Board has been sought in regard to sanitation, and in all cases the suggestions made have been readily complied with.

The Board would respectfully call to mind the fact that householders are required by law, no less than physicians, to report cases of contagious disease occurring within their respective families.

#### WESTBOROUGH.

In no instance has the Board been forced to resort to legal measures to secure compliance with its requests.

The general health of the inhabitants of the town has been comparatively good. There has been no epidemic disease, and only four cases of contagious disease dangerous to the public health have been reported.

## WESTFIELD.

At the town meeting, held April 8, it was voted :—

That the Board of Health is hereby instructed to compel persons owning, leasing or maintaining any building, to connect with the public sewer, as provided in chapter 132 of the Acts of 1890, on or before the first day of January, 1895.

After mature deliberation your Board decided that the best interests of the public health demanded immediate action, and instructed its clerk to formulate a notice for compulsory entrance. Five hundred of these notices were sent to property owners on the south side of Westfield River. Entrances were made the entire season as rapidly as the property owners could secure attention from the plumbers and drain-layers. Three hundred and fifty-four sewer applications were made, representing the entrance of three hundred and seventy-one buildings, which includes five hundred and eighteen families, besides eight blocks, two churches, one school building, three shops and one stable.

The Board established certain limits in the town, within which the keeping of swine was prohibited, and provided that any and all swine, and any pen or other inclosure in which swine are kept, outside of said districts, shall be kept in a condition of neatness and cleanliness acceptable to the Board of Health.

## WESTFORD.

The physicians were prompt in notifying the Board of all infectious or contagious diseases, and where quarantine was established we allowed it to remain until the physician in charge of the case notified us that it was unnecessary. Disagreeable as it was to be shut off from their usual freedom, members of the families where these infectious diseases prevailed readily complied with the regulations, and did much to prevent the spread of the disease. Householders do not seem to understand that the law requires them as well as physicians to notify the Board of Health if they are knowing of infectious or contagious disease within their family or house. The law is very plain, and a heavy penalty is provided for non-compliance with it. But two householders have complied with the law the past year.

## WHITMAN.

The difficulties arising from lack of a sewage system, and the fact that a great deal of the land in Whitman is so low that deep cesspools cannot be dug, have been thoroughly described in preceding reports, and it is hoped that at some future time the desired system may be established. The town has not suffered from many cases of contagious diseases the past year, but *all cases* which have come to our knowledge have been promptly reported

to the State Board of Health, entered on our records and reported to the school committee according to law. When necessary, conspicuous red cards with the name of the disease in large letters have been posted on the premises where an infectious disease was known to exist.

#### WILLIAMSTOWN.

The Board has attended to the usual matter of nuisances, which have been promptly abated. In connection with board of selectmen, the Board of Health has assisted in the construction of sewers, an excellent advance in this matter, and it is hoped that the same policy will be continued during the coming year.

#### WINCHESTER.

The Board vaccinated eighty scholars, sixty-one of whom had never been vaccinated before. Some of these had passed through all but the high school.

The Metropolitan sewer is about complete in Winchester, and we hope our local system of sewers will soon be commenced and that, in the near future, Winchester will be supplied with a complete system.

#### WOBURN.

During the year over one hundred complaints were received, concerning existing nuisances, and promptly attended. Among the most prominent was the Pantasote Leather Company nuisance, which had been a cause of complaint for several years, not only by the citizens of our own city, but also by the citizens of the neighboring towns of Reading, Stoneham, Wilmington, Wakefield and Winchester. After a thorough investigation by the Board, they ordered the premises closed until the proper machinery could be introduced to abate the nuisance. The works have not started again, as yet, nor will they be allowed to until all semblance of a nuisance has been abated. A number of complaints were also received from the inspectors of the Boston Water Board and received prompt attention.

#### WORCESTER.

Number of complaints for the year ending Dec. 31, 1893, 1,713. Rooms fumigated, 448.

There were three successful prosecutions by the Board during the year, viz., one for keeping pigs without a license, one under the law regulating contagious diseases among domestic animals, one for doing plumbing work without a license.

Twelve houses, containing thirty-five tenements, were vacated on account of bad sanitary condition.

The general sanitary condition of the city through the year was good. There was a slight increase in the number of deaths over the previous year.

Special efforts were made during the summer months to thoroughly clean the city in anticipation of an invasion of cholera, but owing to the effective national quarantine maintained by the general government its entrance was prevented. As usual, a large number of the cases of typhoid fever were due to causes outside of the city. It is probable that several cases were contracted at Chicago while visiting the Fair. We again call attention to the great necessity of a hospital for the care of contagious diseases. The need of such an institution has been, if possible, more forcibly brought to our attention during the year just closed by the appearance of contagious diseases in several of the institutions of our city that are devoted to benevolent and charitable purposes, thereby impairing, if not altogether preventing, their usefulness for the time being.

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The board has encouraged in every practicable way the use of the new remedy, antitoxin, and with very gratifying results. The length of the disease, in cases where this remedy was used, has been much reduced, and in some cases lives have been saved which in all probability would have been lost under any other treatment. Of the four fatal cases, two were treated in this way and two were not.

## SOMERVILLE.

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| Number of notices mailed, . . . . .                                    | 480 |
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In addition to the above, many nuisances have been abated on verbal notice from the agent without action by the board, and of which no record has been made.

Six cases of glanders have occurred during the year. Prompt action was taken in every case, and the horses have been killed.

## TAUNTON.

The board has advocated the isolation of suspected cases of diphtheria, especially where there are two or more children in the family or house, without waiting for a full development of the disease.

Early in the year the board of health invited the co-operation of the school teachers to aid in preserving the public health. To this end printed postal cards directed to the board of health were distributed to each teacher, whereon they were to indicate the absence of any pupil with suspected illness. Upon receipt of the card the physician of the board visited the scholar. A large number of cases so indicated have been examined, and, while a large majority of cases found were of the kind incident to childhood, suspicious cases of contagious disease have been found, the child isolated and children in the house kept from school.

## WAKEFIELD.

Regulations for the inspection and testing of plumbing work were made and have been enforced. The result has been highly satisfactory, the quality of the work done being so much improved as to far outweigh the additional cost to the town of having the inspections made. We wish to impress upon the town the absolute necessity of some sewerage system in the very immediate future, as there are in certain portions of the town nuisances that cannot be entirely abated under present conditions.

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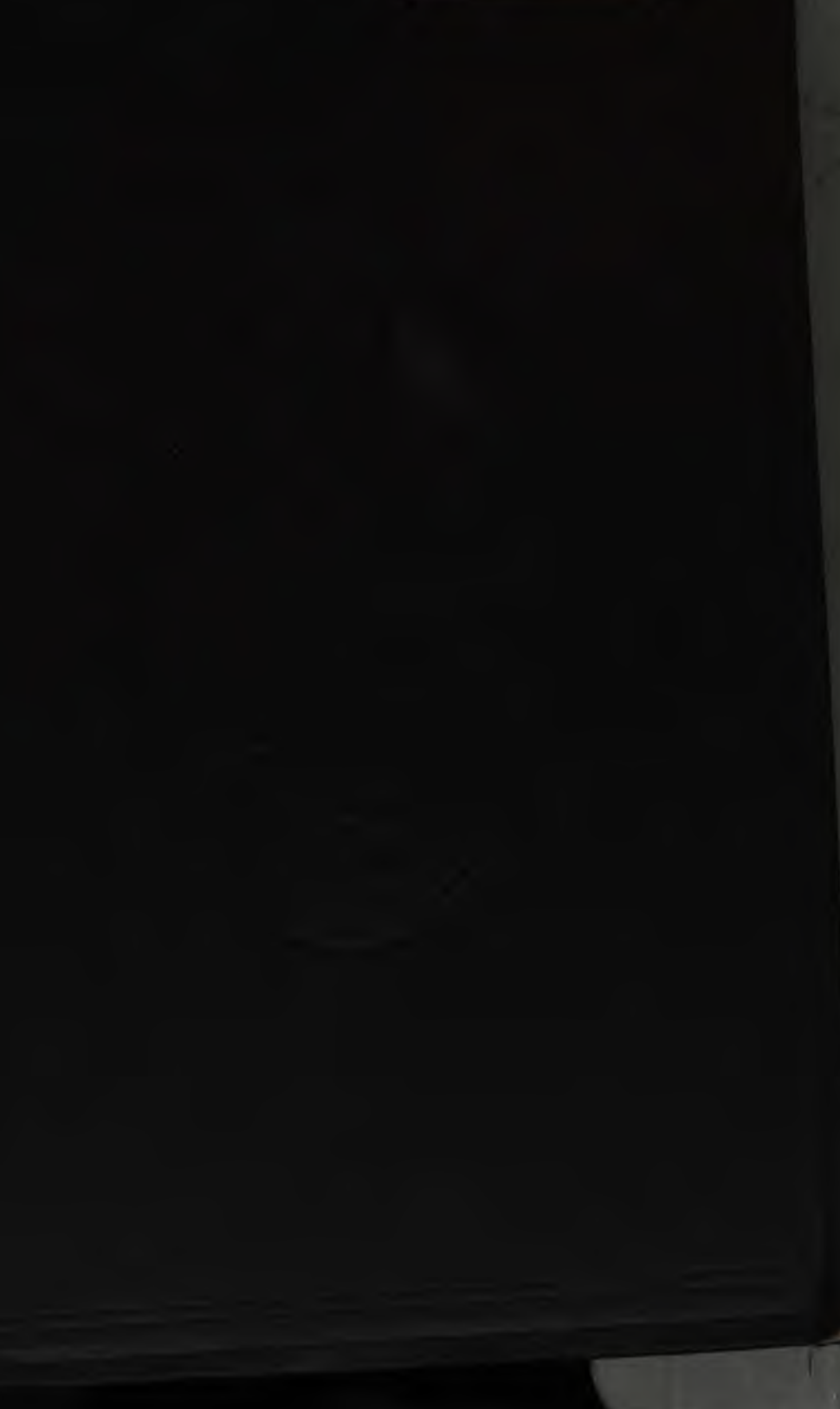
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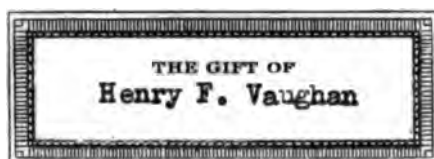
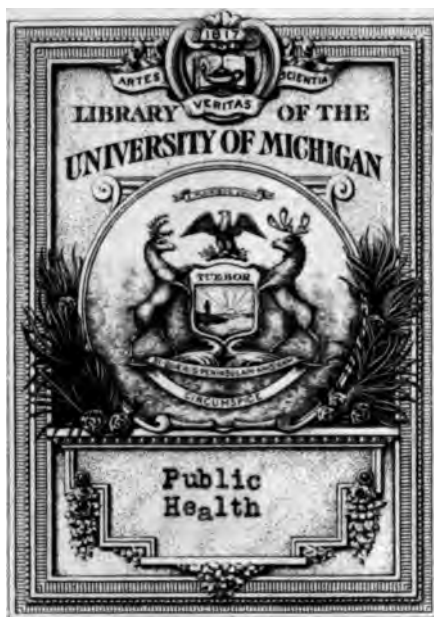












Public Health

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W.C. Head,

Lawrence

Kansas.







**TWENTY-SEVENTH ANNUAL REPORT**

**OF THE**

**STATE BOARD OF HEALTH**

**OF**

**MASSACHUSETTS.**

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**BOSTON :**  
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**1896.**





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1895-1896.

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|                     |                  |   |   |   |   |                |
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Public Health

Gift  
Henry F. Vaughan

4-4-44

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# GENERAL REPORT.

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The contents of the present volume comprise a report of the general work of the State Board of Health for the year ending Sept. 30, 1895, and of that which relates to Water Supply and Sewerage for the calendar year 1895.

This first portion, the general report, paged in Roman numerals, includes a brief statement of the work done under the statutes which define the work of the Board, and contains a summary of the vital statistics of the State for the year 1894.

The second part of the report, paged in Arabic numerals, contains the fuller details of the work of the Board, under the acts relating to Water Supply and Sewerage, Food and Drug Inspection, Reporting of Infectious Diseases and such papers relating to special topics the Board has deemed it desirable to publish.

The following members comprised the Board in 1895 : —

HENRY P. WALCOTT, *Chairman.*

FRANK W. DRAPER.  
HIRAM F. MILLS.  
JAMES W. HULL.

GERARD C. TOBEY.  
CHARLES H. PORTER.  
JULIAN A. MEAD.

Dr. J. A. Mead of Watertown was appointed in October, 1895, to fill the place made vacant by the death of Dr. J. W. Hastings. Dr. F. Mills' term expired in May, 1895, and he was reappointed for seven years.

During the year 1895, in addition to the regular routine work of the Board, the following special lines of work have been prosecuted : —

Under the provisions of chapter 426 of the Acts of 1894, the contract made with the Eastern Dredging Company for the purpose of digging certain portions of the Concord and Sudbury rivers was completed under the direction of the Board.

Under the organic act creating the Board and requiring it to "take cognizance of the interests of health and life among the citizens of the Commonwealth," the Board has provided a continuous supply of anti-toxin, for use throughout the Commonwealth, for the purpose of diminishing the mortality from diphtheria, and in connection with the same work, has organized a bacteriological department for the purpose of experimental and executive work in the investigation of infectious diseases.

The duties of the Board as defined by the statutes have not only been increased but have also been changed in their character since the establishment of the Board in 1869. At that time the work of the Board as set forth in the organic law of June, 1869, was entirely of an advisory nature.

The first act of the Legislature giving to the Board executive powers was the offensive trade act of 1871, whereby the Board was authorized, after due notice and hearing, "and if, in the judgment of the Board, the public health or the public comfort and convenience so required," to order parties to cease and desist from further carrying on such trades or occupations.

By an act of 1878 authority was given to the Board to "have general supervision of water supplies" and to investigate the pollution of them and its causes. It was also empowered to issue orders for the prevention of such pollution. This act was repealed in 1884; but in 1886 another statute was enacted, the scope of which was much broader and more effective in its operation, since it not only authorized the Board to make experiments and investigations in the line of water and sewage purification, but made it incumbent upon all cities, towns, corporations, firms and individuals to seek and obtain competent advice before introducing systems of water supply and sewerage. Liberal appropriations were provided for carrying out its provisions.

In 1882 an act was passed to prevent the adulteration of food and drugs and conferring on the Board the authority to enforce the same. The operations of the Board under this act have been reported in each of the annual reports of the Board during the past thirteen years.

Other acts of minor importance have from time to time been enacted, increasing gradually the executive functions of the Board while its advisory powers have not been diminished. Among the

utes of this character may be named the act relating to ice supplies, the supervision of crematories and the act giving to the Board ordinate powers with local boards of health in the prevention of spread of contagious diseases.

### INFECTIOUS DISEASES.

No serious epidemic occurred during 1895. So far as can be seen from the returns of infectious diseases made to the Board under statutory provisions *diphtheria* had increased slightly over the prevalence of the previous year, but in consequence of improved methods of treatment had not proved so fatal as in former years. Deaths from *scarlet fever* were much fewer than those of either 1893 or 1894, those from *typhoid fever* were slightly less than those of 1893 or 1894, and those from *measles* were greater than those of 1894 but less than those of 1893.

#### *Small-pox.*

During the year 1895 not a single death from small-pox has been reported to the Board, and there was but one recorded case of illness in this disease, as compared with a total of 185 cases and 32 deaths in the previous year. Had this single case been cared for in the State where the disease originated, as ought to have been done, he should have been able to record an absolute immunity from small-pox throughout the year. The patient in this case was a student at Yale College, where he was taken ill and was allowed to return to his home in Massachusetts, travelling through two States by public conveyances. Had unvaccinated persons or those not recently vaccinated been exposed to him on the way, the consequences might have proved disastrous. The facts in this case are presented in conformity to the usual blank form employed in the reports of recent years.

| No. | Place.   | Date of Report. | Nationality.   | Age. | Sex. | Occupation. | Vaccinated. | Number of Scars. |
|-----|----------|-----------------|----------------|------|------|-------------|-------------|------------------|
| 1   | Andover. | March 8         | United States. | 18   | M.   | Student.    | Yes.        | 2                |

*Other States and Provinces.*—While Massachusetts was so nearly exempt from the invasion of small-pox, other States suffered consid-



erably from its presence during the year. In compliance with the interstate resolutions adopted at Toronto in 1886 notices were received from the following States and provinces with reference to the existence of cases of small-pox during 1895, the sum total being at least 1,348 cases: In Maine 1 case, New Hampshire 19, Connecticut 4, Rhode Island 1, New York 2 (also others, the number not stated), Pennsylvania 327, Maryland 60, Ohio 205 (chiefly in Cincinnati), Michigan 45, Illinois 7, Wisconsin 379 (chiefly in Milwaukee), Missouri 267, Tennessee 3, Minnesota 4, Alabama 1, Oklahoma 7, Ontario 16; total, 1,348.

Notices were also received four times during the year from the immigration office at New York of the arrival of the following steamers with cases of small-pox on board: the "Ems" from Bremen, May 28; the "München" from Bremen, June 19; the "Marsala" (mostly Greeks), October 6; the "California" (mostly Italians), December 3.

The names of immigrants on these steamers destined for Massachusetts, with the places of destination, were also forwarded, and were immediately transmitted by the Board to the local boards of health in the cities and towns to which such immigrants were bound.

### *Typhoid Fever.*

The number of requests which have been made for the assistance of the Board in investigating the causes of typhoid fever has materially lessened within the past two years, the cause being undoubtedly due in a great measure to the continuous introduction of new and purer water supplies for domestic use in cities and towns, and the adoption of methods of protecting existing water supplies from pollution and the purification of certain waters by filtration.

The mortality from typhoid fever in 1894 was only 3.1 per 10,000 of the population.

The following figures represent approximately the mortality from this disease in the different counties of Massachusetts in 1894 per 10,000 of the population living in each county. They show not only a lessened mortality as compared with the figures of earlier periods, but also a greater uniformity in the different counties.

*Death Rate per 10,000 Living from Typhoid Fever in Massachusetts (by Counties), 1894.*

|                      |     |                      |     |
|----------------------|-----|----------------------|-----|
| able, . . . . .      | 2.2 | Hampshire, . . . . . | 3.3 |
| ire, . . . . .       | 5.3 | Middlesex, . . . . . | 3.5 |
| , . . . . .          | 2.9 | Nantucket, . . . . . | 0.0 |
| , . . . . .          | 2.4 | Norfolk, . . . . .   | 2.5 |
| . . . . .            | 2.7 | Plymouth, . . . . .  | 2.3 |
| in, . . . . .        | 3.2 | Suffolk, . . . . .   | 2.7 |
| len, . . . . .       | 2.3 | Worcester, . . . . . | 3.3 |
| THE STATE, . . . . . |     | 3.1                  |     |

e of the most common means by which typhoid fever is spread  
 g the population is the milk supply. Epidemics of this char-  
 have been investigated by the Board in recent years in Cam-  
 e, Somerville, Woburn, Springfield, Marlborough and Newton.  
 such epidemics in different years have occurred in Cambridge,  
 them apparently due to infection of the milk supply, either at  
 urce upon the producing dairy farms or at the place of collec-  
 or distribution in the city. Hence the importance of securing  
 reatest care in preventing the occurrence of the disease among  
 ns employed either at the dairies or at the places where the  
 cans are handled and cleaned, at the final place of distribution.  
 erson who has the slightest symptoms of typhoid fever should  
 owed to engage in these occupations until complete recovery  
 ken place. Mild or “ambulant” cases are more dangerous  
 severe cases, in which the sick are confined to bed, since the  
 r are far more liable to infect the milk supply, as has been  
 in the investigations conducted by the Board.  
 e following rules recommended by Dr. Russell, senior medical  
 : of health of Glasgow, would, if everywhere enforced upon  
 farms, diminish very greatly the prevalence of typhoid fever  
 : cities and towns : —  
  
 The first and foremost requirement is absolute cleanliness in all the  
 of dairy work.

2. The cow stable should be of ample size, capable of thorough and frequent cleaning; it should be well lighted, preferably by sunlight, and should be well ventilated.

3. To ensure the greatest freedom from milk infection, the farmhouse should be separated from the buildings used for dairy purposes.

4. No person who is suffering from an infectious disease (or one which conveys any suspicion of infection), or who has been in any way in communication with an infected person or thing, should engage in the milk business.

5. The milk of sick animals, or of those which have suspicious eruptions about the udder or teats, should not be sold for food for human beings.

6. The udder and teats, if soiled, should be washed before milking; warm water, soap and towels should be at hand for the use of milkers, who should be instructed to use them before milking.

7. Healthy cattle, healthy attendants, and, above all, perfect cleanliness in dairy work mean money both to the producer and to the retailer of milk.

The following table presents the statistics of mortality from typhoid fever in the cities of Massachusetts from 1871 to 1894, with the mean annual death rates from this cause in five-year groups.

The table shows a notable decrease in the mean annual death rate from typhoid fever in the four years 1891-94, as compared with the period immediately preceding.

Deaths and Death Rates per 10,000 Living, from Typhoid Fever, in Cities of Massachusetts, 1871-94.

|                        | 1871-1875. |                                           | 1876-1880. |                                           | 1881-1885. |                                           | 1886-1890. |                                           | DEATHS. |       |       |       | Total Deaths, 1891-94. | Mean Annual Death Rate for 4 Years. | Total Deaths, 1891-94. | Mean Annual Death Rate for 4 Years. | Total Deaths, 1891-94. | Mean Annual Death Rate for 4 Years. |
|------------------------|------------|-------------------------------------------|------------|-------------------------------------------|------------|-------------------------------------------|------------|-------------------------------------------|---------|-------|-------|-------|------------------------|-------------------------------------|------------------------|-------------------------------------|------------------------|-------------------------------------|
|                        | Deaths.    | Mean Annual Death Rate per 10,000 Living. | Deaths.    | Mean Annual Death Rate per 10,000 Living. | Deaths.    | Mean Annual Death Rate per 10,000 Living. | Deaths.    | Mean Annual Death Rate per 10,000 Living. | 1891.   | 1892. | 1893. | 1894. |                        |                                     |                        |                                     |                        |                                     |
| Boston, . . . . .      | 1,145      | 7.7                                       | 680        | 3.9                                       | 952        | 6.1                                       | 818        | 3.9                                       | 152     | 137   | 136   | 137   | 602                    | 2.4                                 | 602                    | 2.4                                 | 4,167                  |                                     |
| Worcester, . . . . .   | 176        | 7.8                                       | 131        | 4.9                                       | 106        | 3.8                                       | 109        | 3.8                                       | 16      | 17    | 50    | 31    | 94                     | 2.4                                 | 94                     | 2.4                                 | 616                    |                                     |
| Lowell, . . . . .      | 521        | 9.8                                       | 243        | 4.3                                       | 243        | 7.9                                       | 396        | 11.2                                      | 78      | 77    | 50    | 51    | 261                    | 6.4                                 | 261                    | 6.4                                 | 1,238                  |                                     |
| Fall River, . . . . .  | 176        | 9.8                                       | 162        | 6.4                                       | 174        | 6.6                                       | 209        | 6.4                                       | 49      | 27    | 18    | 31    | 125                    | 3.1                                 | 125                    | 3.1                                 | 836                    |                                     |
| Cambridge, . . . . .   | 124        | 5.7                                       | 65         | 2.2                                       | 103        | 3.7                                       | 116        | 3.6                                       | 17      | 15    | 18    | 28    | 78                     | 2.1                                 | 78                     | 2.1                                 | 476                    |                                     |
| Lynn, . . . . .        | 118        | 7.8                                       | 72         | 4.1                                       | 109        | 5.2                                       | 66         | 2.2                                       | 12      | 13    | 13    | 11    | 49                     | 1.7                                 | 49                     | 1.7                                 | 404                    |                                     |
| Lawrence, . . . . .    | 190        | 11.9                                      | 123        | 6.6                                       | 144        | 7.4                                       | 233        | 11.2                                      | 65      | 60    | 39    | 25    | 169                    | 7.0                                 | 169                    | 7.0                                 | 858                    |                                     |
| Springfield, . . . . . | 314        | 14.8                                      | 86         | 5.3                                       | 117        | 6.6                                       | 88         | 4.3                                       | 16      | 39    | 17    | 15    | 87                     | 3.6                                 | 87                     | 3.6                                 | 593                    |                                     |
| New Bedford, . . . . . | 99         | 8.4                                       | 60         | 3.8                                       | 62         | 4.1                                       | 71         | 3.8                                       | 9       | 15    | 29    | 13    | 66                     | 2.8                                 | 66                     | 2.8                                 | 348                    |                                     |
| Somerville, . . . . .  | 69         | 7.6                                       | 33         | 2.8                                       | 45         | 3.3                                       | 49         | 2.8                                       | 13      | 14    | 13    | 14    | 64                     | 2.4                                 | 64                     | 2.4                                 | 250                    |                                     |
| Holyoke, . . . . .     | 157        | 23.3                                      | 77         | 8.1                                       | 159        | 12.8                                      | 105        | 6.6                                       | 25      | 16    | 10    | 7     | 68                     | 3.1                                 | 68                     | 3.1                                 | 454                    |                                     |
| Salem, . . . . .       | 87         | 6.9                                       | 61         | 4.0                                       | 66         | 4.7                                       | 69         | 4.0                                       | 9       | 18    | 17    | 11    | 55                     | 3.4                                 | 55                     | 3.4                                 | 328                    |                                     |
| Chelsea, . . . . .     | 86         | 8.7                                       | 36         | 3.4                                       | 37         | 3.1                                       | 35         | 2.6                                       | 9       | 10    | 6     | 7     | 82                     | 2.2                                 | 82                     | 2.2                                 | 298                    |                                     |
| Haverhill, . . . . .   | 86         | 8.7                                       | 36         | 3.4                                       | 37         | 3.1                                       | 35         | 2.6                                       | 7       | 13    | 13    | 8     | 41                     | 2.8                                 | 41                     | 2.8                                 | 258                    |                                     |
| Brockton, . . . . .    | 43         | 9.2                                       | 14         | 2.3                                       | 41         | 4.8                                       | 46         | 3.8                                       | 11      | 8     | 3     | 7     | 29                     | 1.9                                 | 29                     | 1.9                                 | 173                    |                                     |
| Taunton, . . . . .     | 63         | 6.7                                       | 34         | 3.3                                       | 69         | 5.3                                       | 58         | 4.7                                       | 3       | 9     | 4     | 8     | 27                     | 2.1                                 | 27                     | 2.1                                 | 243                    |                                     |
| Newton, . . . . .      | 20         | 2.6                                       | 25         | 3.0                                       | 31         | 3.4                                       | 44         | 4.0                                       | 7       | 4     | 6     | 10    | 25                     | 1.9                                 | 25                     | 1.9                                 | 145                    |                                     |
| Malden, . . . . .      | 25         | 5.5                                       | 31         | 5.4                                       | 21         | 3.0                                       | 33         | 3.3                                       | 6       | 6     | 6     | 12    | 29                     | 2.2                                 | 29                     | 2.2                                 | 189                    |                                     |
| Fitchburg, . . . . .   | 32         | 5.4                                       | 17         | 2.8                                       | 18         | 2.6                                       | 31         | 3.3                                       | 6       | 3     | 6     | 6     | 15                     | 1.2                                 | 15                     | 1.2                                 | 113                    |                                     |
| Gloucester, . . . . .  | 61         | 6.3                                       | 34         | 3.8                                       | 38         | 3.7                                       | 25         | 2.2                                       | 3       | 3     | 6     | 3     | 14                     | 1.1                                 | 14                     | 1.1                                 | 162                    |                                     |
| Waltham, . . . . .     | 13         | 2.7                                       | 8          | 1.5                                       | 20         | 3.0                                       | 17         | 2.0                                       | 3       | 6     | 2     | 2     | 21                     | 1.2                                 | 21                     | 1.2                                 | 70                     |                                     |
| Pittsfield, . . . . .  | 56         | 9.6                                       | 29         | 4.5                                       | 34         | 4.9                                       | 40         | 5.0                                       | 5       | 6     | 6     | 6     | 21                     | 2.2                                 | 21                     | 2.2                                 | 180                    |                                     |
| Quincy, . . . . .      | 19         | 4.6                                       | 21         | 4.3                                       | 27         | 4.8                                       | 37         | 5.1                                       | 6       | 7     | 11    | 7     | 30                     | 3.2                                 | 30                     | 3.2                                 | 134                    |                                     |
| Northampton, . . . . . | 46         | 8.7                                       | 19         | 3.3                                       | 29         | 4.6                                       | 22         | 3.2                                       | 2       | 3     | 6     | 4     | 15                     | 1.9                                 | 15                     | 1.9                                 | 131                    |                                     |
| Chicopee, . . . . .    | 63         | 12.6                                      | 35         | 6.5                                       | 48         | 8.4                                       | 43         | 6.7                                       | 9       | 24    | 10    | 3     | 46                     | 6.0                                 | 46                     | 6.0                                 | 225                    |                                     |
| Newburyport, . . . . . | 29         | 4.5                                       | 31         | 4.6                                       | 22         | 3.2                                       | 17         | 2.5                                       | 6       | 3     | 7     | 6     | 21                     | 2.9                                 | 21                     | 2.9                                 | 120                    |                                     |
| Marlborough, . . . . . | 27         | 6.7                                       | 20         | 4.3                                       | 20         | 3.8                                       | 32         | 5.2                                       | 4       | 3     | 7     | 10    | 24                     | 3.3                                 | 24                     | 3.3                                 | 128                    |                                     |
| Woburn, . . . . .      | 26         | 6.7                                       | 10         | 2.0                                       | 14         | 2.5                                       | 24         | 3.8                                       | 7       | 8     | 4     | 5     | 24                     | 3.6                                 | 24                     | 3.6                                 | 98                     |                                     |
| Medford, . . . . .     | 11         | 3.6                                       | 12         | 3.4                                       | 11         | 2.6                                       | 14         | 2.2                                       | 3       | 2     | 6     | 4     | 14                     | 2.2                                 | 14                     | 2.2                                 | 69                     |                                     |
| Everett, . . . . .     | 6          | 4.1                                       | 2          | 1.0                                       | 9          | 3.6                                       | 14         | 3.3                                       | 4       | 1     | 4     | 3     | 12                     | 1.6                                 | 12                     | 1.6                                 | 43                     |                                     |
| Beverly, . . . . .     | 18         | 5.2                                       | 13         | 3.3                                       | 10         | 2.3                                       | 10         | 2.0                                       | 2       | 3     | 1     | 2     | 8                      | 1.4                                 | 8                      | 1.4                                 | 59                     |                                     |
| Totals, . . . . .      | 3,458      | 8.2                                       | 2,077      | 4.2                                       | 2,821      | 5.1                                       | 5,907      | 4.5                                       | 551     | 556   | 506   | 494   | 2,067                  | 2.8                                 | 2,067                  | 2.8                                 | 13,360                 |                                     |

*Malarial Fever.*

In addition to the appearance of malarial fever at different points in the State, as detailed in previous reports of the Board, reports have been received by the Board during the past year relative to its appearance in two additional localities, at North Saugus and at Uxbridge.

Notice of its appearance at North Saugus came to the Board in the form of a petition, stating that the city of Lynn had constructed reservoirs in North Saugus for the storage of water, and was about to build another, also that malarial fever had been prevalent in that village since their construction. The petitioners therefore requested the Board "to investigate the matter and to take such action as may be necessary." With a view to affording relief to the petitioners the Board caused an investigation to be made at North Saugus. A house to house visit was made, which resulted in the finding, among a population of about 200 persons, that there had been 21 cases of intermittent fever in 1894 and in the first six months of 1895 there were 13 more. It was also stated that there had been many more cases in 1892 and in 1893. Five households had escaped, mostly on higher ground.

In compliance with this petition the Board held a hearing in August, 1895, at which the board of health of Saugus was represented, together with other citizens of that town and the superintendent of the water works of Lynn. As a result of the hearing, and in view of the facts elicited upon the petition relative to the construction of a new reservoir by the Lynn water board in North Saugus and the effects of such construction on the health of the adjacent community, and in consideration of the methods described by the constructing engineer and the superintendent of said water board with reference to the preparation of the proposed basin and its connections, it was voted "that the State Board of Health deems further action on its part with reference to the new reservoir unnecessary, under existing conditions."

Later in the year information was received that malarial fever was prevailing in Uxbridge, and a request was received from the local board of health of that town that the State Board would investigate the same. An agent was sent to Uxbridge and the investigation is in progress at the time of writing this report.

### *Consumption.*

in keeping with the progress of medical science, and especially with the important discoveries which have been made in the history of infectious diseases, their causes and prevention, the methods of detecting the existence of consumption and the measures taken to prevent its spread form an important part.

Improvements in ventilation in the hygiene of industrial operations, the proper selection and inspection of the food supply, the adoption of improved climatic conditions, the management of dust in the household and workshop, and above all in the proper disposal and destruction of the sputa of the sick, all have without doubt had marked effect in steadily diminishing the mortality from this destructive disease.

In the last annual report (page lxxv *et seq.*) a summary of the vital statistics of consumption was presented, in which its steady diminution during a period of nearly a half century was shown.

With a view of diffusing popular information upon the best methods of preventing tuberculosis the Board issued the following circular in January, 1895, which was distributed throughout the State to health persons (chiefly physicians and boards of health) as would be most likely to appreciate its value and place the circular where it would prove useful in the prevention of the disease.

#### **CIRCULAR OF THE STATE BOARD OF HEALTH RELATIVE TO TUBERCULOSIS OR CONSUMPTION AND THE BEST MEANS FOR PREVENTING IT.**

The object of the State Board of Health in issuing the following circular is to furnish information (1) as to the nature of pulmonary consumption, the conditions which favor its spread, and (3) the best methods of preventing it.

##### *1. — As to the Nature of Consumption.*

Consumption is the most destructive disease of New England, the number of persons annually dying from this cause in Massachusetts amounting nearly six thousand. Modern research places it among infectious diseases.

The specific virus or poison of the disease consists of a minute germ, the bacillus of tuberculosis," which exists in the tissues and expectoration of the sick, and which may in various ways enter the bodies of the well and produce the disease in them. In the proper care and disposal of the expectoration of the sick, it is probable, lies one of the chief methods of preventing the spread of the disease.

## 2. — *Conditions which favor the Spread of Consumption among Human Beings.*

*Defective ventilation.* One of the chief conditions which is favorable to the production of consumption is the continuous and habitual breathing of unrenewed air. Consequently, in workshops, factories, school rooms, public buildings, halls, churches, and the inhabited apartments of dwellings and tenement-houses the absence of adequate means of ventilation favors the spread of consumption.

*Dampness of soil* on which the house stands, and dampness of the immediate neighborhood are favorable conditions for the production of consumption. The occupancy as living or sleeping rooms of apartments which are constantly damp or are partly or wholly underground, undoubtedly has a similar effect.

*Overcrowding* in dwellings, in factories, and in workshops where men and women work for several hours each day, is also a favorable condition for spreading the disease. Density of population increases the liability to this disease. Observations in Massachusetts extending over a period of twenty years (1871-90) show that the deaths from consumption in densely settled districts, as compared with those in sparsely settled districts of the State stood in the ratio of 1,000 deaths in the former to 727 in the latter.

Another factor which favors the spread of this disease is the presence of *dust* in the air of apartments, factories, mills and workshops. Hence occupations or trades in which men, women or children are exposed to the inhalation of irritating dust increase the liability to contract the disease among such operatives. An examination of the reports of the Registrar General of England for several successive years shows that fishermen, who are of all classes the least exposed to dust inhalation, are also comparatively exempt from consumption.

*Insufficient and badly selected food.* While the influence of improper and insufficient feeding upon the predisposition to consumption is not so directly proven as are the effects of certain other conditions, there is yet sufficient evidence to show that a restricted diet or one composed exclusively of single elementary constituents, as for example, the starches alone, and these in too limited quantities, probably predisposes to consumption.

*Intemperance* in the use of alcoholic stimulants has also been shown to act in the same direction.

Undue physical or mental strain, overwork, worry and anxiety, and the prolonged suckling of infants (beyond ten or twelve months) are conditions contributing to the same end.

## 3. — *Preventive Measures.*

Having the foregoing predisposing conditions in view, the measures which are essential for the prevention of this disease may be more clearly understood

1. *The prevention of overcrowding.* In tenements and in dwelling-houses the prevention of overcrowding diminishes the liability to contract tubercular diseases among the occupants.

Hence the adoption of measures which shall counteract the effect of overcrowding is desirable. Ventilation is one of the most efficient of such measures. Adequate ventilation should be provided in all factories, halls, school-houses and other buildings in which people assemble in considerable numbers. Simple methods of ventilation in the living and sleeping rooms of dwellings are also essential to healthy living. Open fireplaces, movable grates in sleeping rooms, provision for admitting fresh air at the windows by special means are all useful precautions.

2. *Household as well as personal cleanliness* is essential to the prevention of consumption. The removal of dust from floors should be practised and care should be taken that such dust is removed by such means as will ensure the least diffusion through the air of rooms during their occupancy.

3. *Occupations.* The selection of a healthy occupation is a matter of small importance.

Sedentary occupations in ill-ventilated apartments and those which expose the workman to the inhalation of dust should be avoided. Different sorts of dust vary in harmful effects. The sharp dust produced in the grinding of needles and steel tools and in the mining of metals is especially irritating, and the mortality from consumption among operatives in such industries is high. Operatives engaged in such occupations may diminish the liability to harm by wearing "respirators" over the mouth and nose, while at work.

In several factories where consumption had made serious inroads upon the operatives, the adoption of measures for the prevention of a dusty atmosphere secured a marked diminution of the prevalence of this disease among the workmen employed in them.

Regular daily exercise in the open air is of the first importance for all persons who are engaged in sedentary occupations.

The owners and superintendents of *factories, mills and workshops* can accomplish much toward the prevention of tuberculosis among the operatives by the introduction of adequate systems of ventilation and heating, and by the use of hard, smooth floors without cracks or crevices.

The dust should be removed from the floors at night, after working hours, and not during the occupancy of the workrooms. The use of moisture in the removal of dust, and careful wiping with damp cloths is preferable to sweeping up the dust when dry. Spitting upon the floor should be forbidden.

4. *Food.* As an essential requisite to the prevention of consumption, diet of sound, wholesome food, in which the chief elementary forms of nutriment are harmoniously combined (the fats, starches and proteids) is necessary. Such a diet should consist mainly of bread and the various



cereals with butter and other fats in generous measure, together with meat, fish and fruits. This does not imply a luxurious or expensive diet, but rather one that is nutritious and easily digested.

The question of the effect of the use of the *meat* and *milk* of *tuberculous animals* does not yet appear to be so well settled as to admit of an unqualified conclusion.

In the absence of absolute and definite evidence, it is therefore desirable that the *meat* of all suspected animals should be cooked thoroughly before using it as food. The *milk* of such animals should be entirely excluded from the food supply.

5. *Overwork, anxiety, worry and exhaustion* should be avoided. Mothers should be advised to *wean suckling infants* by the end of the first year.

### *Disposal of Sputa.*

6. With reference to those who are sick with consumption or tuberculosis, and especially with reference to the possibility that their presence among other human beings may prove a source of danger on account of infection, the following recommendation as to the disposal of the expectoration of consumptives should be especially noted.

Observation and experiments have demonstrated the fact that in this expectoration (especially when dried) lies the chief danger of infection, and hence its proper disposal becomes a matter of prime importance. Therefore, sputa should never be allowed to become dry, and should be destroyed as quickly as possible. Consumptives should be instructed not to expectorate about rooms, in streets or highways, in railway or street cars, or in vehicles of any sort, but should spit into rags which can be burned, or into cups or other receptacles containing a little water or other material which may be thoroughly disinfected before the same is allowed to pass into the drain or sewer. Such receptacles should be cleansed with boiling water.

A healthy person should not sleep in the same room with a consumptive.

### *Disinfection.*

7. Sputa may best be burned when deposited upon pieces of cloth or rags; and when put into cups or receptacles holding water the whole should be disinfected with a saturated solution of carbolic acid, which may be obtained of any reliable druggist.

Disinfection should be practised in the case of rooms or apartments which have been vacated by consumptives or those in which such persons have died. There is a growing belief, supported by observation, that rooms which have been inhabited by consumptive families may become permanently infected, and ought not to be occupied until radical measures have been taken to cleanse and disinfect them. Each room vacated by a

erulous patient should be disinfected and especially the floor and er parts of the walls. For this purpose washing the floor and all wood-k with a corrosive sublimate solution, one part to one thousand (about teaspoonful to a gallon of water) should be practised, and the bed and hing of the last occupant should be submitted to steam disinfection or boiling water. Strong soapsuds also have efficient disinfecting power, may be used for washing floors and woodwork. The disinfection ald be thoroughly done, but especially so in cases where the habits of consumptive in regard to disposal of his sputa have been careless.

as a means of spreading information upon this important subject, local rds of health can undoubtedly accomplish much toward the prevention onsumption, by issuing a circular like the following:—

*The Prevention of Consumption.*

onsumption is the most destructive disease of New England, the number of ons dying annually from this cause in Massachusetts amounting to nearly thousand.

The disease is infectious, and can be communicated from one person to another. chief danger exists in the expectoration of the sick, and if this expectoration arefully destroyed little danger need be feared.

Consumptives should be instructed not to spit upon the floors of rooms, public s, street and railway cars, and other vehicles, nor in the streets, but into pieces cloth, or receptacles made for the purpose, containing water, or a saturated tion of carbolic acid (one part of carbolic acid crystals to about fifteen parts of er). Such bits of cloth should be destroyed by fire, before the sputa become , and other receptacles should be cleansed with scalding water, their contents ing been destroyed or otherwise carefully disposed of. Handkerchiefs which y have been used from necessity should be boiled half an hour before washing. A healthy person should not sleep in the same room with a consumptive. Remember that sputa must never be allowed to become dry.

OFFICE OF THE STATE BOARD OF HEALTH, BOSTON.  
January, 1895.

LOCAL BOARDS OF HEALTH.

Nearly fifty years ago (1850) the sanitary commission of Massa- usetts advised the obligatory appointment of boards of health in ery city and town in the State, and after the establishment of the ate Board of Health in 1869 this Board frequently called attention the need of legislation having this end in view. But not until 1877 was legislation enacted requiring such boards to be appointed a compulsory measure, and even then the requirement applied to ties only. The Board has from time to time urged the necessity further legislation requiring similar action on the part of towns, d especially in the case of those having large populations.

No substantial advance has been made in this direction, however, until the enactment of a law in 1894, of which the following is a copy. This statute (chapter 218, Acts of 1894) was amended later in the session, by the same Legislature, so that the amended act reads as follows : —

[Chapter 218, Acts of 1894, as amended by chapter 473, Acts of 1894.]

**AN ACT PROVIDING FOR THE ELECTION OF BOARDS OF HEALTH IN TOWNS.**

**SECTION 1.** Every town in the Commonwealth may elect a board of health by ballot at the annual meeting of the town, or at a meeting legally warned for the purpose, consisting of three persons, to serve, one for the term of three years, one for the term of two years and one for the term of one year, beginning with the first Monday in April then next ensuing and until their respective successors are chosen and qualified; and thereafter such town shall, at its annual town meeting, choose in the same manner one person who shall hold office for three years from the first Monday of April then next ensuing, and until another is chosen and qualified in his stead. If no such board is chosen the selectmen shall constitute such board of health.

Section 2 was repealed by chapter 473 of 1894.

**SECTION 3.** In each city and town having a population of more than five thousand inhabitants, as determined by the last census, at least one member of said board shall be a physician, and the board shall send an annual report of the deaths in such town to the state board of health. The form of such reports shall be prescribed and furnished by the state board of health.

**SECTION 4.** Section three of chapter eighty of the Public Statutes is hereby repealed. Sections two, twenty-one, twenty-eight, twenty-nine, thirty, thirty-one, thirty-two, thirty-three, thirty-four and thirty-five of chapter eighty of the Public Statutes, and sections one and two of chapter three hundred and thirty-eight of the acts of the year eighteen hundred and eighty-seven, are hereby amended by striking out the words "or health officer," wherever the same occur therein. [*Approved April 7, 1894.*]

The formation of an organization known as the Massachusetts Association of Boards of Health has proved a decided stimulus to local boards in consequence of the advantages secured to its members by means of mutual discussion of the many questions which are constantly occurring in the work of municipal sanitary administration. The members of this organization consist mainly of the members of local boards of health, and of such other persons as are especially interested in public hygiene. Meetings have been held quarterly during the past five years or more, and at each meeting

as relative to the work of municipal boards have been presented for discussion. Committees have been appointed to confer with relative health committees with reference to matters of importance which appear to require further legislation.

The association publishes a quarterly journal in which its transactions appear.

#### OFFENSIVE TRADES.

Two complaints were made to the Board during the year under the provisions of the acts relating to offensive trades, and consequently hearings were held. The board of health of Newburyport rejected the advice of the State Board in regard to a rendering establishment in that city, situated at some distance from the populous part of the city. The secretary conferred with the secretary of the local board, and on visiting the establishment in question found it in an extremely filthy condition, both internally and externally, some twenty or forty carcasses of horses in different stages of decomposition lying unburied upon the surface of the ground, while many others, efficiently buried, had been uncovered by dogs.

Information was received that the premises were subsequently put in good condition and that no further complaints had been made in relation to the same.

#### LOCAL NUISANCES.

A very considerable part of the correspondence received by the Board consists of letters from individuals, or of petitions signed by a greater or less number of citizens, requesting the State Board to remove the local nuisances existing in cities and towns. Often such letters and petitions call the attention of the State Board to the fact that the local board of health has been requested to abate the nuisance but has either refused or neglected to attend to the matter.

So frequent has this class of correspondence become that the State Board has issued a circular which is used as a reply to letters of this character, calling attention to the fact that the State Board has no power or authority to abate an ordinary local nuisance, but that the power is conferred upon the local board of health to take all proper measures in such cases. If the local board of health refuses or neglects to comply with the request of the petitioners, then the matter may be referred to the county commissioners under the provisions of chapter 80, sections 36, 37 and 38, but not to the State Board of Health.

### FOOD AND DRUG INSPECTION.

The importance of an abundant and wholesome food supply, in the preservation of the health and strength of a population, cannot be over-estimated.

The operations of the Board under the provisions of the food and drug acts have in each year from 1883 to the present year been made the subject of a special report, in which are presented the essential particulars of the work accomplished during the year. This report upon food and drug inspection presents a tabular summary of the entire work from 1883 to 1895 inclusive, together with the report of prosecutions submitted to the Legislature, and the reports of the analysts for the year ending Sept. 30, 1895.

From this report it appears that 7,309 samples of food and drugs were examined during the year, at a total cost for inspection, collection, analysis and prosecution of \$11,375.89.

The number of prosecutions conducted in the same year was 92, and the number of convictions was 86, or 93.5 per cent.

### BACTERIOLOGICAL WORK AND ORGANIZATION OF DEPARTMENT.

Hitherto, the principal department of bacteriological investigation conducted by the Board has chiefly been the examination of drinking water supplies with reference to their possible contamination with the germs of typhoid fever and kindred diseases, but the rapid advances which have been made in recent years in the investigation of the natural history of other infectious diseases, and the methods of their prevention and the consequent lessening of mortality from these causes, have led to the extension of this work into other fields.

In the last report of the Board (page cvii) reference was made to the work which had been initiated by the Board for the production of antitoxin and its distribution to boards of health throughout the State. For this purpose the services of Dr. J. L. Goodale were secured. He entered upon his duties with enthusiasm and successfully carried out the plans which the Board had designed with this end in view. To his energy much is due for the successful initiation of this new and important line of work. Since, however, it appeared desirable to enlarge the scope of this department, it was deemed best to obtain the services of an expert, who could devote his whole time

to bacteriological work and at the same time conduct investigations in such new fields of inquiry as might be presented.

For this purpose the Board appointed Dr. Theobald Smith of Washington, D.C., formerly Chief of the Division of Pathology of the Bureau of Animal Industry of the Department of Agriculture. A laboratory was established in the building known as the Bussey Institution, near the Forest Hills station of the New York, New Haven & Hartford Railroad, where facilities were also offered for stabling and caring for the horses required for antitoxin production.

More recently the work of examination of cultures in suspected cases of diphtheria was entered upon, and still later the examination of sputa suspected of containing the bacilli of tuberculosis. The appearance of malarial fevers in regions hitherto uninvaded has also suggested the examination of the blood of malarial patients, and with this end in view circulars have been issued to local boards of health offering the services of this department in making the necessary diagnostic examinations.

A report upon the production of antitoxin may be found among the special papers in this volume, and in the next annual report further information will be given in relation to the other branches of bacteriological investigation.

#### LEAD POISONING BY MEANS OF THE USE OF LEAD PIPE FOR THE CONVEYANCE OF DRINKING WATER.

In a State in which one hundred and fifty municipalities are supplied with water from nearly as many distinct and separate sources, the quality of the water furnished to consumers presents very many points of difference, as is specially shown by the reports of the Board upon the examination of water, issued during the past seven years.

In the present report (page 30) reference is made to the present water supply of one town (Kingston), where a considerable number of cases of lead poisoning occurred during the past year.

The water furnished to consumers in this town appears to have acted with unusual power upon lead pipes, especially upon those which were comparatively new. It was also found on investigation that lead pipe was used in Kingston to an unusual degree for house connections with the street pipes, and long lines of such service pipes, several hundred feet in length, were employed in not a few instances.

These facts, together with a careless use of water which had been allowed to stand in the pipes over night, undoubtedly accounted for the cases of illness, some of which were severe.

An investigation is now being conducted by the Board with reference to the question of lead poisoning by drinking water supplies in general, and will be reported upon in a future report.

**THE STATE BOARD OF HEALTH EXHIBIT AT THE COTTON STATES  
AND INTERNATIONAL EXPOSITION AT ATLANTA, GEORGIA.**

The following invitation was received in August, 1895, from the Secretary of the Board of Managers representing Massachusetts at the Atlanta Exposition:—

BOSTON, MASS., Aug. 21, 1895.

*To the Secretary, Massachusetts Board of Health, State House, Boston.*

DEAR SIR:—It is the desire of this Board that your department make an exhibit at the Cotton States and International Exposition, Atlanta, Ga., to be located in the State building to be erected on the Exposition grounds. We understand that you are willing to make an exhibit of this kind.

If convenient, as a matter of record, we should like to know what exhibits you intend to or can make conveniently. I suppose it will be scarcely possible for you to give this statement in much detail at this time. Can you make an approximate estimate of the probable cost of such an exhibit to the State, including of course, the getting of it to Atlanta, putting it up, and properly returning it into your possession?

Very truly yours,

HENRY G. KITTREDGE,

*Secretary.*

The Board accepted the invitation thus tendered to them and placed the work of preparing the exhibit in charge of Prof. Wm. T. Hedgwick, who had successfully managed the Board's exhibit of 1893 at the Columbian Exhibition at Chicago.

Ample room was furnished for the exhibit in the second story of the Massachusetts building at the Atlanta Exposition.

The material of this exhibit was essentially the same as that which was presented at the Exposition at Chicago in 1893, and was detailed in the twenty-fifth annual report of the Board (page xviii), with such additions as represented the progress made by the Board in its sanitary work during the two years which had elapsed since the World's Fair. These were chiefly the maps, plans and report

showing the Metropolitan water supply, plans of the filter for purifying the city water supply of Lawrence, photographs of the anti-toxin laboratory at Forest Hills, and plans of the more recent systems of sewage disposal adopted by cities and towns since 1893.

The directors of the Exposition, acting upon the suggestion of the jury of award, awarded the grand prize, or gold medal, to the State Board of Health "for a comprehensive exhibit of the means and methods adopted by the Board to promote the health of the people of the State and the country."

### MANUAL OF HEALTH LAWS.

The Board has published, at intervals of three or four years since 1882, a digest of the laws relating to public health in force in this Commonwealth, each revision containing all of the new health statutes and amendments up to the date of publication, together with such decisions of the supreme court as have been made upon cases which have been referred to it under these statutes. This manual has proved a very useful aid to the work of local boards of health, as well as to all persons connected with or interested in sanitary work.

### WATER SUPPLY AND SEWERAGE.

The engineering department of the Board was established in 1886, by authority of the new power conferred upon the Board by the enactment of chapter 274 of the Acts of that year. F. P. Stearns, C.E., was appointed as engineer of the Board in September, 1886, and continued as its engineer till August, 1895, when he was appointed engineer of the Metropolitan Water Board, and X. H. Goodnough was appointed engineer of the State Board of Health.

It is difficult to estimate the extent of the useful results accomplished under the provisions of this act during the ten years since it became a law of the Commonwealth.

An experiment station has been established for the purpose of investigating the important subjects of filtration of water and of sewage; thousands of samples of water, of sewage, of sands, gravels and other soils have been examined; rivers, brooks, ponds, lakes and springs have been visited and investigated in reply to applications for advice with reference to their usefulness for the purposes of water supply or to the prevention of their pollution; hearings and conferences



city and town authorities have been frequently held, and advice been given under the statutes to municipal authorities, corporations, firms and individuals in at least four hundred instances, and in cases in which the value involved has ranged from that represented by some comparatively small seashore water supply to those of the large cities involving several millions of dollars.

In this department have been planned several of the most important and extensive schemes relative to the water supply and sewerage of large communities.

These were the North Metropolitan sewerage system, providing for the sewage disposal of eighteen municipalities, most of which are on the Charles River. This plan was reported to the Legislature in 1889, and was then ordered to be constructed and is now in operation. The cost of the works has been about \$5,500,000.

The planning of the Metropolitan water supply was entrusted to the Board and was reported upon in 1895, and is now in course of construction.

This extensive work will provide a water supply for twenty-eight municipalities, containing at present about one million inhabitants, at an estimated cost of \$27,000,000.

Other duties entrusted to the Board of a similar nature were the improvement of the Concord and Sudbury rivers, the improvement of the Neponset River, the reporting of a system of sewerage and sewage disposal for Salem and Peabody, and, in connection with the Metropolitan Park Commission, the improvement of the lower portions of the Charles River, and later still, as a joint Board with the Harbor and Land Commission, an investigation of the Green Harbor and marshes.

The work of the Board in this department for the year 1895 is presented in this report. It includes the following topics: Advice to cities and towns, details of the examination of water supplies and rivers, summary of water supply statistics and records of rain, the hardness of water and methods by which it is determined, experiments upon the purification of sewage and water at the Lawrence Experiment Station, methods of determining the numbers of bacteria in sewage and water, and an account of the sewage disposal works now in operation in the State.

**THE SANITARY CONDITION OF THE NEPONSET MEADOWS.**

During the session of the Legislature of 1895 a hearing was held by the legislative committee on public health with reference to the condition of the Neponset meadows and their effect upon the public health. These meadows occupy a large extent of territory upon both banks of the Neponset River from Walpole through the towns of Norwood, Canton, Hyde Park and Milton, nearly to the sea.

As a result of this hearing the Legislature enacted the following resolve : —

[CHAPTER 83 OF THE RESOLVES OF 1895.]

**RESOLVE DIRECTING THE STATE BOARD OF HEALTH TO INVESTIGATE THE  
SANITARY CONDITION OF THE NEPONSET MEADOWS.**

*Resolved*, That the state board of health be directed to investigate the sanitary condition of the meadows of the Neponset river and the beds, shores and waters of said river in the towns of Canton, Sharon, Norwood, Dedham, Milton and Hyde Park, and report whether their condition is dangerous or injurious to the public health by reason of stagnant water or refuse from manufactories, or other causes. If said board shall find that the condition of the meadows or of the beds, shores or waters is dangerous or injurious to the public health, they shall recommend some plan for improving their sanitary condition and for the removal of any nuisance therefrom, and report the same to the next general court. The board may expend a sum not exceeding three thousand dollars in carrying out the provisions of this resolve. [*Approved May 9, 1895.*]

Investigations with reference to the subject contemplated by this resolve were still in progress at the time of printing this report.

**THE SEWAGE DISPOSAL AND DRAINAGE OF SALEM AND PEABODY.**

The Legislature of 1895, after consideration of a petition from the mayor of Salem for a commission to report upon a system of sewerage and sewage disposal for Salem and Peabody, enacted the following resolve : —

[CHAPTER 112 OF THE RESOLVES OF 1895.]

**RESOLVE RELATIVE TO SEWAGE DISPOSAL AND DRAINAGE IN SALEM AND  
PEABODY.**

*Resolved*, That the state board of health is hereby authorized and directed to consider and report a general system of drainage and sewerage for the city of Salem and town of Peabody, or for such parts of said city and town

t all of which shall be wholly within either of said municipalities, as may, the opinion of said board, be best drained by said system. It shall be a duty of said board :— First. To designate the portions of said city and town which shall be tributary to and embraced in the district and system to be so reported, and to define the same by their report, with plans and maps. Second. To define and show, by suitable plans and maps, such trunk line and main branches as it shall recommend to be constructed, with outlet. Third. To consider the various methods of disposal of sewage and the application of such methods to any portion of the territory herein mentioned ; and to define the methods by which said city and town, or parts of said city and town, may utilize said trunk line and main branches as an outlet of a stem of sewerage and drainage for said city and town and said parts of said city and town respectively ; and to show the same by plans and maps. Fourth. To employ such engineering and other assistance as may be necessary for carrying out the objects of this resolve, and to cause such surveys and levels to be made as will enable said board to determine with accuracy the location and grades of said trunk line and main branches, and to cause such surveys and levels in said city and town, and parts of said city and town, as will enable said board to determine with accuracy the methods which said city and town, and parts of said city and town, may respectively utilize said trunk line and main branches, and to report such methods and plans showing the main lines by which each may so provide for itself a stem of sewerage and drainage with its outlet into said trunk line or main branches. Fifth. To define the size and capacity of said trunk line and main branches, and the materials of which they should be constructed and manner of construction, and such other particulars as will enable said board to determine the probable expense thereof ; and to ascertain and report the cost of the construction of said trunk line and main branches and outlet, and to report a recommendation as to the methods of apportioning said cost. All expenses incurred by said board under the provisions of this resolve shall be reported to the governor and council, and all such expenses when proved by them shall be paid out of the treasury of the Commonwealth ; but the total expenditure shall not exceed three thousand dollars. The Commonwealth shall be reimbursed for such expenditure under this resolve when it shall have been approved by the governor and council in the following manner :— The town of Peabody and the city of Salem shall each pay such proportion of the above expenditure as the said board shall deem to be equitable, and the amounts so to be paid by each shall be assessed and collected by the treasurer of the Commonwealth at the time required for the payment of the state tax of said town and said city respectively. Said board shall make all reports required by this resolve to the general court on or before the first Wednesday of January in the year eighteen hundred and ninety-six. [Approved May 29, 1895.]

The State Board of Health began the work required by the foregoing resolve in June, 1895, but the time within which the report was to have been submitted to the Legislature being insufficient for the work in hand, the succeeding Legislature extended the time to July 1, 1896.

#### HEALTH OF TOWNS.

A digest of the principal facts of importance published in the annual reports of local boards of health occupies the final pages of this report. The table containing the number of cases and deaths from certain infectious diseases with the ratio of fatality has been transferred from this portion of the report to that part which is entitled "Statistical Summaries of Disease and Mortality."

#### ROUTINE WORK OF THE BOARD.

During the year ending Sept. 30, 1895, the Board held meetings at least once in each month during the year. Meetings of such of the standing committees as were necessary for the transaction of business were also held from time to time, as well as joint sessions with such other boards or commissions as were prescribed by the Legislature.

The office of the Board has been open throughout the year, as prescribed by the Public Statutes, chapter 21, section 10,\* for the transaction of its authorized business.

Advice has been very frequently given at the office and by mail to local boards and to individuals in regard to sanitary matters, and many visits have been made by the secretary, the engineers and other experts to cities and towns for the purpose of making investigations and giving advice.

The work of the office has become materially increased during the year, in consequence of being made a central office for the distribution of antitoxin to local boards of health, hospitals and physicians in private practice.

The statistics of mortality compiled from the weekly postal card returns from the registering authorities of cities and towns have been published weekly during the year in the form of a bulletin, which also contains, once in each month, a report of the work done in the line of food and drug inspection, together with the prosecutions

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\* Office hours, 9 A.M. to 5 P.M. ; Saturdays, 9 A.M. to 2 P.M.

der the food and drug acts, and other important information to the work of this department. In addition to these items also published in the same bulletin a weekly report of the of cases of infectious diseases reported by the local boards State Board of Health.

Following table presents certain statistical data relative to the work of the Board : —

#### STATISTICAL TABLE FOR THE YEAR ENDING SEPT. 30, 1895.

|                                                                      |            |
|----------------------------------------------------------------------|------------|
| number of samples of foods and drugs examined during the year,       | 7,309      |
| of milk examined (included in the foregoing), . . . . .              | 3,794      |
| number examined since beginning of work in 1883, . . . . .           | 67,756     |
| number of samples of milk examined since beginning of work . . . . . | 34,421     |
| of prosecutions against offenders during the year, . . . . .         | 92         |
| of convictions during the year, . . . . .                            | 86         |
| of fines secured during the year, . . . . .                          | \$2,625 00 |

#### Employed in general work of Board at central office, State House : —

|                        |   |
|------------------------|---|
| Secretary, . . . . .   | 1 |
| Chief Clerk, . . . . . | 2 |
| Manager, . . . . .     | 1 |
| —                      | — |
| Total, . . . . .       | 4 |

#### Employed at central office, State House, Boston, for food and drug

|                                                   |   |
|---------------------------------------------------|---|
| Commissioners, chemists and assistants, . . . . . | 2 |
| Total, . . . . .                                  | 1 |
| —                                                 | — |
| Total, . . . . .                                  | 3 |
| —                                                 | — |
| Total, . . . . .                                  | 6 |

#### Employed at laboratory (Bussey Institute) : —

|                       |   |
|-----------------------|---|
| Analyst, . . . . .    | 1 |
| Assistants, . . . . . | 3 |
| —                     | — |
| Total, . . . . .      | 4 |

#### UNDER THE PROVISIONS OF CHAPTER 375, ACTS OF 1888.

##### Requests for advice from cities, towns and others : —

|                                                |    |
|------------------------------------------------|----|
| Requesting to water supply, . . . . .          | 38 |
| Requesting to sewerage and drainage, . . . . . | 9  |
| Requesting to pollution of streams, . . . . .  | 5  |
| —                                              | —  |
| Total, . . . . .                               | 52 |

|                                                                                                                            |               |
|----------------------------------------------------------------------------------------------------------------------------|---------------|
| Number of samples of water examined chemically and microscopically at the Massachusetts Institute of Technology, . . . . . | 2,250         |
| Number of samples of sewage and water examined chemically and bacterially at the Lawrence Experiment Station, . . . . .    | 2,594         |
| Number of samples of sand examined chemically and bacterially at the Lawrence Experiment Station, . . . . .                | 227           |
| Number of samples of sand examined mechanically at the Lawrence Experiment Station, . . . . .                              | 49            |
| Additional samples examined bacterially at the Lawrence Experiment Station. . . . .                                        | 6,078         |
| <b>Total number of samples examined, . . . . .</b>                                                                         | <b>11,193</b> |

**Force employed at central office: \*—**

|                                     |            |
|-------------------------------------|------------|
| Chief engineer, . . . . .           | 1          |
| Assistant engineers, . . . . .      | 2          |
| Stenographers and clerks, . . . . . | 2          |
|                                     | <b>— 5</b> |

**At Massachusetts Institute of Technology: —**

|                                |            |
|--------------------------------|------------|
| Chief chemist,† . . . . .      | 1          |
| Assistant chemists, . . . . .  | 5          |
| Chief biologist,† . . . . .    | 1          |
| Assistant biologist, . . . . . | 1          |
|                                | <b>— 8</b> |

**At Lawrence Experiment Station: —**

|                                          |             |
|------------------------------------------|-------------|
| Chemists, . . . . .                      | 2           |
| Bacteriologists, . . . . .               | 3           |
| Other assistants and laborers, . . . . . | 5           |
|                                          | <b>— 10</b> |

**Total ordinary force employed under chapter 375, Acts of 1888, . . . . . 23**

**Total ordinary force in all departments, . . . . . 37**

The number of applications for advice under the provisions of chapter 275, Acts of 1888, received since July, 1886, when the act relating to water supply and sewerage first went into operation, is as follows: —

|                 |    |                         |            |
|-----------------|----|-------------------------|------------|
| 1886, . . . . . | 8  | 1892, . . . . .         | 56         |
| 1887, . . . . . | 22 | 1893, . . . . .         | 51         |
| 1888, . . . . . | 28 | 1894, . . . . .         | 53         |
| 1889, . . . . . | 38 | 1895, . . . . .         | 52         |
| 1890, . . . . . | 23 |                         |            |
| 1891, . . . . . | 53 | <b>Total, . . . . .</b> | <b>384</b> |

\* Not including the force employed upon the metropolitan water supply investigations, improvement of the Charles, Concord and Sudbury and Neponset rivers, or Salem and Peabody sewerage.

† The chief chemist and biologist, although located at the Massachusetts Institute of Technology, have the oversight of the chemical and biological work at the Lawrence Experiment Station.

## RECOMMENDATIONS.

The following recommendation was made to the Legislature at the beginning of the session of 1896: —

The Board recommends the continuance of its investigations now being carried on as authorized by the provisions of chapter 375 of the Acts of 1888. For this purpose, and to make the necessary investigations in order to advise cities, towns, corporations and individuals in regard to the best methods of assuring the purity of intended or existing water supplies and the best method of disposing of sewage, and to carry out the other provisions of chapter 375 of the Acts of 1888, the Board estimates that the sum of \$30,000 will be required.

## EXPENDITURES.

The work of the Board is conducted under the provisions of several statutes, and for its different departments of work these appropriations are annually made, one for the general work of the board, one for the inspection of food and drugs and a third for carrying out the provisions of chapter 375 of the Acts of 1888, relating to the protection of the purity of inland waters. In addition to the foregoing, special appropriations have been made from time to time, on occasion has demanded, for the purpose of enabling the Board to conduct special lines of investigations.

The appropriations for the different departments of work in 1895 were as follows: —

|                                                                 |                 |
|-----------------------------------------------------------------|-----------------|
| For the general work of the Board, . . . . .                    | \$15,800        |
| For food and drug inspection, . . . . .                         | 11,500          |
| For carrying out the provisions of chapter 375, Acts of 1888, . | 30,000          |
| Total, . . . . .                                                | <u>\$57,300</u> |

In addition to the foregoing regular lines of work the Board was authorized to expend a sum not exceeding \$3,000 for carrying out the provisions of a resolve directing the Board to "investigate the sanitary condition of the Neponset meadows,"\* and a similar amount for the purpose of devising a system of "sewage disposal and drainage in Salem and Peabody."†

\* Chapter 83 of the Resolves of 1895.

† Chapter 112 of the Resolves of 1895.

The expenditures in 1895 under the foregoing appropriations were as follows : —

*General Expenditures Sept. 30, 1894, to Sept. 30, 1895.*

|                                                             |            |
|-------------------------------------------------------------|------------|
| Salaries, . . . . .                                         | \$4,820 00 |
| Travelling expenses, . . . . .                              | 841 99     |
| Stationery, . . . . .                                       | 192 73     |
| Printing, . . . . .                                         | 1,472 65   |
| Books, subscriptions and binding, . . . . .                 | 196 89     |
| Typewriting and library supplies, . . . . .                 | 18 18      |
| Telephone, . . . . .                                        | 89 45      |
| Telegrams, . . . . .                                        | 5 95       |
| Postage, . . . . .                                          | 234 21     |
| Postal orders, . . . . .                                    | 7 38       |
| Express, . . . . .                                          | 178 97     |
| Advertising, . . . . .                                      | 35 15      |
| Wrapping paper and twine, . . . . .                         | 27 39      |
| Copy press, . . . . .                                       | 30 00      |
| Zinc plates, etc., . . . . .                                | 35 92      |
| Extra services, . . . . .                                   | 45 00      |
| Drafting diagrams, . . . . .                                | 22 00      |
| Services of messenger, . . . . .                            | 323 78     |
| Special investigations, . . . . .                           | 325 92     |
| Cooking utensils and enamelled ware for analysis, . . . . . | 17 19      |
| Ice collection for analysis, . . . . .                      | 2 40       |
| Chemical examinations, . . . . .                            | 9 00       |
| Recording temperatures of Charles River, . . . . .          | 2 00       |
| J. W. Smith (weather reports), . . . . .                    | 75 00      |
| Sundry office supplies and incidental expenses, . . . . .   | 297 25     |
| Inspection services, . . . . .                              | 30 00      |
|                                                             | <hr/>      |
|                                                             | \$9,336 40 |

*Expenditures at Bacteriological Laboratory.*

|                                                     |             |
|-----------------------------------------------------|-------------|
| Salaries, . . . . .                                 | \$1,845 69  |
| Extra services, . . . . .                           | } 22 00     |
| Services, . . . . .                                 |             |
| Labor (care horses, etc.), . . . . .                | 197 10      |
| Travelling, . . . . .                               | 24 92       |
| Apparatus, chemicals and supplies, . . . . .        | 2,244 02    |
| Purchase of horses and other animals, . . . . .     | 199 85      |
| Board of horses, . . . . .                          | 596 32      |
| Express, . . . . .                                  | 11 79       |
| Telephone, . . . . .                                | 30          |
| Postage, . . . . .                                  | 71          |
| Stationery, . . . . .                               | 2 99        |
| Duties and charges on imported apparatus, . . . . . | 36 92       |
| Copy press, . . . . .                               | 27 65       |
| Mailing cases, . . . . .                            | 4 60        |
|                                                     | <hr/>       |
|                                                     | 5,214 86    |
|                                                     | <hr/>       |
|                                                     | \$14,551 26 |



*Under Chapter 375 of Acts of 1888 (Protection of Purity of Inland Waters) for Calendar Year 1895.*

including wages of laborers at Lawrence Experiment Sta-

|                                               |             |
|-----------------------------------------------|-------------|
|                                               | \$24,147 50 |
| and materials,                                | 1,995 01    |
| oms at Massachusetts Institute of Technology, | 687 50      |
| wrence Experiment Station (eleven months),    | 137 50      |
| expenses,                                     | 1,285 51    |
| arges,                                        | 708 54      |
| s and office, Lawrence Experiment Station,    | 235 84      |
| onery and drawing materials,                  | 513 37      |
| prints and photographs,                       | 88 65       |
| llecting samples,                             | 17 30       |
| mps,                                          | 72 08       |
| i, telegrams and telephone messages,          | 15 22       |
|                                               | 95 96       |
|                                               | <hr/>       |
|                                               | \$29,999 98 |

*For Food and Drug Inspection for Year ending Sept. 30, 1895.*

|                                   |             |
|-----------------------------------|-------------|
| analysts,                         | \$4,500 01  |
| inspectors,                       | 3,963 32    |
| expenses and purchase of samples, | 1,825 00    |
| and chemicals,                    | 911 76      |
|                                   | 4 00        |
|                                   | 2 40        |
|                                   | 2 80        |
| ces,                              | 45 00       |
| all supplies,                     | 29 60       |
| ces,                              | 92 00       |
|                                   | <hr/>       |
|                                   | \$11,375 89 |

H. P. WALCOTT,  
H. F. MILLS,  
F. W. DRAPER,  
G. C. TOBEY,  
J. W. HULL,  
C. H. PORTER,  
J. A. MEAD.



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IMPROVEMENT OF THE CONCORD AND SUDBURY RIVERS.

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## IMPROVEMENT OF THE CONCORD AND SUDBURY RIVERS.

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In the last annual report of the Board (page cviii) reference was made to the enactment of a statute of 1894 providing that the Board should conduct certain operations upon the Concord and Sudbury rivers for the purpose of improving the condition of the meadows along their banks.

After conducting this work as directed, the Board made the following report to the General Court in February, 1896, under the title House Document No. 891 : —

### COMMONWEALTH OF MASSACHUSETTS.

Boston, Feb. 6, 1896.

The improvement of the Concord and Sudbury rivers has been carried on under the authority of chapter four hundred and twenty-six of the acts of one hundred and ninety-four, section one, which is as follows : —

The State Board of Health is hereby authorized and directed to expend during the present year a sum not exceeding twenty thousand dollars, in dredging the Concord and Sudbury rivers above the dam at North Billerica and removing the weeds from said rivers, and in such other measures as shall, in the opinion of the board, tend to the restoration of the marshes along the said rivers to their original condition and to the abatement of malaria and other perils to the health arising from the present state of the same. [*Approved May 24,*

It is also provided in the act that one-half the expense incurred shall be borne by the owners of lands benefited by the improvement, the other half being borne by the state.

The portion of the Concord and Sudbury rivers referred to extends from a point across the Concord River at North Billerica for a distance of about five miles up-stream to a point in Wayland. Within this distance there are a large number of bars over which the water was only from two feet in depth in the summer season. At these shallow places there is usually a rank growth of weeds, greatly obstructing the flow of the

The subject of the improvement of these meadows has been brought to the attention of the legislature from time to time for many years. Old reports refer to petitions to the legislature in sixteen hundred and thirty-six and again in sixteen hundred and forty-five, on account of the wetness of these meadows. Other petitions in seventeen hundred and forty-two, seventeen hundred and eighty-nine and eighteen hundred and sixteen are also referred to, and previous to eighteen hundred and sixteen and since that time there has been much litigation between the meadow owners and the owners of the dam at North Billerica and the city of Boston, which formerly let down water from compensating reservoirs in Hopkintown and Marlborough. During the years from eighteen hundred and fifty-nine to eighteen hundred and sixty-two the matter was before the legislature, and in eighteen hundred and sixty an act (chapter two hundred and eleven) was passed, appointing three commissioners with authority to lower the dam at North Billerica thirty-three inches. In eighteen hundred and sixty-one by chapter one hundred and fifty-four the act of eighteen hundred and sixty was suspended until the first day of May, eighteen hundred and sixty-two, and a commission was appointed to ascertain whether the dam at North Billerica caused the flooding of the meadows. The report of this commission and its extended surveys formed the basis for the act of the legislature in eighteen hundred and ninety-four. Some of its conclusions were as follows:—

“Fourth. Neither any change which can be made in the height of the dam, nor removing the dam altogether, will, alone, afford substantial relief to the meadows.

“Fifth. Keeping the river clear of weeds will, alone, in the ordinary state of the river, reduce the level of the water surface at the great meadows in Wayland and Sudbury six inches; but this will not afford substantial relief to the meadows.

“Sixth. Removing all obstacles to the flow of the water except the dam at North Billerica, and leaving the dam at its present height, will not substantially relieve the meadows.

“Eighth. The meadows can be effectually relieved only by reducing the height of the dam thirty-three inches or more; cutting out the Fordway and other bars, and deepening the shallow places in the river to such an extent that they shall cease to form any obstruction to the free passage of the water in the ordinary condition of the river; straightening the channel in a few places; and thereafter keeping the river free from weeds. In this way the meadows may be so relieved as to become fit for cultivation and valuable.”

The expenses of this commission amounted to \$18,730. Chapter one hundred and forty of the acts of eighteen hundred and sixty-two repealed the act of eighteen hundred and sixty for removing the dam.

on the passage of the act of eighteen hundred and ninety-four the board took the matter immediately under consideration and succeeded in carrying out the original plans made by the commission of eighteen hundred and eighty-one, also a profile showing the effect of various changes, such as the raising of the dam, the removal of weeds and the excavation of the bars, in addition to the lowering of the dam. Note-books containing the original plans were also obtained.

The method of operating the water power at North Billerica during the period covered by the investigations was found to be for some reason entirely different from what it was in 1861, the water in the millpond under ordinary river conditions now being drawn from twelve to eighteen inches below the top of the flashboards in the day time, but filling up and running freely over the flashboards again at nine or ten o'clock at night; whereas in 1861 the water was almost invariably above the top of the flashboards throughout the day except when the water was purposely maintained at a low level. In account of this change in the method of operation, the old report gives little information as to the effect of lowering the water at the dam during the day by the ordinary operation of the mills upon the water in the pool above the Fordway bar.

The diversion of water from the Sudbury River watershed by the city of Boston has caused a lowering of the water in the summer season along the river below the point of diversion, so that the conditions in this respect are different from what they were in 1861. The conditions, on the other hand, were found to be such that the board found it necessary to make an investigation to determine how great an improvement of the river could be effected by the expenditure of \$20,000 and whether the probable result to be obtained would warrant the expenditure proposed.

The investigations indicated that with a higher flow than often occurs during July and August it was not probable that the water at Farm Bridge and Island would stand more than two feet two inches above the level of the flashboards of the dam at North Billerica, unless water was being drawn from the dams of the Boston waterworks into the river below in addition to the small amount which the city of Boston is required to let run in the river. With the flow of water which makes the height of the water at Farm bridge two feet two inches above the level of the top of the flashboards, the depth of the water flowing over the flashboards in the morning was not more than five inches; consequently, the height of the water at Farm bridge with this amount of water flowing was only one foot nine inches above the level of the water in the millpond just above the dam. As no stream will flow unless the water has a slope, it was obvious that the most extended improvement of the river which could be made without lowering the water at the dam would lower the water at Farm bridge less than one foot nine

The first bars upon the stream above North Billerica begin about eighteen hundred feet from the dam, where there is a narrow rocky channel extending for a distance of five hundred feet up-stream. About four hundred feet above its upper end and about half a mile from the dam is the Fordway bar, which extends for a distance of seven hundred feet up-stream. About six hundred feet above the Fordway bar is Pollard's bar, which is about half as long as the Fordway bar and at a considerably lower level. The total fall over these bars in the morning when the water was flowing over the flashboards at the dam was found to be only about three inches, and any improvement which could be made at these bars with the sum which would be available would have been sufficient to lower the water only a very small amount at this place unless there was also a lowering of the dam.

In the course of the investigations it was learned that during the summer season the quantity of water which can be utilized in daytime at the dam is limited by the obstruction caused by the Fordway bar and the narrow rocky channel below it. Owing to these obstructions the mills cannot use in the daytime the full flow of the river during the twenty-four hours, for a portion of it runs to waste over the flashboards at night. If these obstructions should be partially or wholly removed, the mills could use a greater proportion of the total flow of the river and the water power would be benefited thereby. There was some question, therefore, whether in view of this benefit the mill owners might not be willing to lower their flashboards by an amount dependent upon the improvement of the channels, and in case such an arrangement had been made the river above the Fordway bar would have received the full benefit of the lowering of the flashboards and a slight additional lowering due to the greater capacity of the channel through the bar; but the bars in the vicinity were found to be composed of hard material which would have been expensive to move and would have limited the improvement in the rest of the river to such a degree that a satisfactory and permanent improvement of the channel above could not have been made with the amount of money available; and in view of all the circumstances the conclusion was reached that the money could best be spent in dredging the bars in the river farther up.

Several plans were considered, one of which provided for cutting a channel thirty feet wide on the bottom through the bars in Concord below the Assabet River, and twenty feet wide on the bottom through the bars above the Assabet, as far as the bar just above Farm bridge. The bottoms of these channels were to be five feet below the water level after the improvement had been completed; but it was not proposed to make any channel through a few bars where the depth was about four feet, as the depth of water over these bars was so great that they did not obstruct the flow of the water in more than a slight degree. A depth of five feet was decided upon to prevent the future obstruction of the channel by weeds.



ovement proposed, it was estimated, would make no change in the water below Barrett's bar in Concord. Above this point be a reduction in the height of the water of five inches at the the Sudbury and Assabet rivers, nearly six inches from a point ars in Concord to a point just below Robbins' bar, seven inches Robbins' bar, and ten and one-half inches at Farm bridge. ants were estimated upon the basis of a fairly high summer is unusual in July and August, though it is exceeded in wet

int of lowering of the river that could be obtained was so small deciding to enter upon the work the Board consulted with the ners, who were to pay half the cost, as to whether this amount ; of the surface of the river was sufficient in their opinion to expenditure. A meeting was held July 26, 1894, and the mated to the meadow owners by the Board. The meadow owners, g the opinion of the Board as to the amount of improvement that omplished by the proposed plan, held a meeting and subsequently e Board that it was their earnest desire that the plan be car-proposed. Upon the meadow owners expressing a desire that ould be done as proposed, the Board at once prepared plans and for proposals for the excavation of the proposed channels, and a s awarded August 30, 1894, for the excavation of the various rate of  $33\frac{1}{2}$  cents per cubic yard. The contractor, however, urchase satisfactory sureties, bids were again asked for and the bsequently awarded to the Eastern Dredging Company, who s at the time the contract was previously awarded and were now idders, at 48 cents per cubic yard. The contract was made 22, 1894, the contractors agreeing to complete the work by De- 895. The time required for the preparation and transportation y to Concord to begin the work was such that owing to the late- season the beginning of the work was postponed until the spring en the dredging in the stream was begun April 4. The work was from this time until the twenty-first of December, and the all the bars up to the canal bridge in Wayland was completed. e bars dredged, with the total number of cubic yards removed is given in the following table :—

to payment has been made for dredging done in the month of  
r after the date fixed in the contract for the termination of the

|                                                       |             |
|-------------------------------------------------------|-------------|
| tion, . . . . .                                       | \$20,000 00 |
| f engineers and assistants, including prelim-         |             |
| vestigation and the inspection of the work, .         | \$2,935 35  |
| g expenses and subsistence of engineers, .            | 330 83      |
| ern Dredging Company, . . . . .                       | 11,791 20   |
| . . . . .                                             | 195 86      |
| ons of gauges, . . . . .                              | 59 05       |
| for boats . . . . .                                   | 24 15       |
| g instruments and repairs, . . . . .                  | 9 20        |
| r and postage, . . . . .                              | 3 90        |
| materials, . . . . .                                  | 6 33        |
| plans, . . . . .                                      | 5 90        |
| . . . . .                                             | 43 65       |
| ne and other supplies, . . . . .                      | 20 13       |
| ge, . . . . .                                         | 2 20        |
| e and telegraph messages, . . . . .                   | 11 14       |
| . . . . .                                             | 15,438 89   |
| ice unexpended, . . . . .                             | \$4,561 11  |
| of amount of work done after December 1, .            | \$992 90    |
| er cent held back from monthly estimates, .           | 2,256 02    |
|                                                       | 3,248 92    |
| ice to apply for dredging above Canal bridge, . . . . | \$1,312 19  |
| are no other outstanding bills.                       |             |

aterial dredged has been disposed of generally by dumping it into  
at places where it is wide and deep ; but material taken from the  
bar and much of that from the Canal bar was deposited upon the  
f the meadows near the river.

remain to be dredged between 3,000 and 4,000 yards in order to com-  
work as planned, and I estimate that if the amount unexpended is re-  
sted there will still be needed an additional appropriation of \$1,000.  
ging of a portion of the Canal bar under the Canal bridge will  
e omitted unless the bridge is removed, because any movement of  
under or near the bridge would be likely to cause it to collapse.

Respectfully submitted,

X. H. GOODNOUGH,

*Acting Chief Engineer.*



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**THE**

**AL STATISTICS OF MASSACHUSETTS**

**FOR 1894.**

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## THE VITAL STATISTICS OF MASSACHUSETTS FOR 1894.

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In the last report of the Board the subject of the vital statistics of the population was treated with greater fulness of detail than had been devoted to this subject in previous reports in consequence of the increasing demand for information of this character, as well as on account of the fact that vital statistics form the basis upon which a very large share of sanitary science is founded.

In the present summary a similar method of treating the subject will be employed with that which was followed in presenting the tables for 1893, some of the longer tables being omitted.

### POPULATION.

Since the population forms the standard or basis of comparison in statements of vital statistics a brief statement of the population will be presented in the following summary:—

The census of Massachusetts is taken every five years, that of 1870, 1880, 1890, etc., by the general government, and that of the intervening periods, 1885, 1895, etc., by the State.

The present summary of the vital statistics of 1894, although relating to a year previous to the taking of the State census, has the advantage of the census of 1895 as a basis of comparison, since greater accuracy is secured by estimating the population in a year intervening between two census years than in estimating that of a year following a census year, the population at a future census being unknown.

The population of Massachusetts in 1890 was 2,238,943, and that of 1895 was 2,500,183, the rate of increase (geometric) between the census years having been a little over 2.23 per cent. annually. Of the total population of 2,500,183 in 1895 1,214,701 were males and 1,285,482 were females.

The following table presents the summary of the census and estimated populations of the State from 1842 to 1895, together with the numbers of marriages, births and deaths in each year up to and including 1894.

The marriage, birth and death rates for the same years are also given, together with the excess of births over deaths in each year.

TABLE 1. — *Marriages, Births and Deaths in Massachusetts (1842-1894), with Population and Rates per 1,000 Living.*

| YEARS.              | Population. | Marriages. | Births. | Deaths. | Excess of Births over Deaths. | Persons Married to 1,000. | Births to 1,000 Persons. | Deaths to 1,000 Persons. | Excess Rate of Births over Deaths. |
|---------------------|-------------|------------|---------|---------|-------------------------------|---------------------------|--------------------------|--------------------------|------------------------------------|
| *1841-42, . . . . . | 783,116     | 5,742      | 8,571   | 9,544   | -                             | -                         | -                        | -                        | -                                  |
| *1842-43, . . . . . | 806,862     | 5,807      | 8,750   | 10,684  | -                             | -                         | -                        | -                        | -                                  |
| *1843-44, . . . . . | 831,328     | 4,304      | 14,767  | 8,338   | -                             | -                         | -                        | -                        | -                                  |
| *1844-45, . . . . . | 856,536     | 4,863      | 15,711  | 8,844   | -                             | -                         | -                        | -                        | -                                  |
| *1845-46, . . . . . | 882,508     | 5,263      | 16,486  | 12,114  | -                             | -                         | -                        | -                        | -                                  |
| *1846-47, . . . . . | 909,267     | 5,390      | 17,097  | 14,492  | -                             | -                         | -                        | -                        | -                                  |
| *1847-48, . . . . . | 936,838     | 5,287      | 16,515  | 15,609  | -                             | -                         | -                        | 17.17                    | 5.54                               |
| †1848, . . . . .    | -           | 4,015      | 12,540  | 12,475  | -                             | -                         | -                        | 19.58                    | 5.16                               |
| †1849, . . . . .    | 965,245     | 6,936      | 25,773  | 20,423  | 5,350                         | -                         | 26.70                    | 21.16                    | 5.54                               |
| 1850, . . . . .     | 994,514     | 10,345     | 27,664  | 16,606  | 11,058                        | 20.80                     | 27.82                    | 16.70                    | 11.12                              |
| 1851, . . . . .     | 1,020,673   | 11,966     | 28,661  | 18,934  | 9,727                         | 23.44                     | 28.08                    | 18.55                    | 9.53                               |
| 1852, . . . . .     | 1,047,520   | 11,578     | 29,802  | 18,482  | 11,320                        | 22.10                     | 28.45                    | 17.64                    | 10.81                              |
| 1853, . . . . .     | 1,075,072   | 12,828     | 30,920  | 20,301  | 10,619                        | 23.86                     | 28.76                    | 18.88                    | 9.88                               |
| 1854, . . . . .     | 1,103,350   | 13,683     | 31,997  | 21,414  | 10,583                        | 24.80                     | 29.00                    | 19.41                    | 9.59                               |
| 1855, . . . . .     | 1,132,389   | 12,329     | 32,845  | 20,798  | 12,047                        | 21.77                     | 29.01                    | 18.37                    | 10.64                              |
| 1856, . . . . .     | 1,151,461   | 12,265     | 34,445  | 20,734  | 13,711                        | 21.30                     | 29.91                    | 18.00                    | 11.91                              |
| 1857, . . . . .     | 1,170,864   | 11,789     | 35,320  | 21,280  | 14,040                        | 20.05                     | 30.16                    | 18.17                    | 11.99                              |
| 1858, . . . . .     | 1,190,584   | 10,527     | 34,491  | 20,776  | 13,715                        | 17.68                     | 28.97                    | 17.45                    | 11.52                              |
| 1859, . . . . .     | 1,210,657   | 11,475     | 35,442  | 29,976  | 14,466                        | 18.96                     | 29.28                    | 17.33                    | 11.95                              |
| 1860, . . . . .     | 1,231,087   | 12,404     | 36,051  | 23,068  | 12,983                        | 20.15                     | 29.28                    | 18.74                    | 10.54                              |
| 1861, . . . . .     | 1,238,177   | 10,972     | 35,445  | 24,085  | 11,360                        | 17.72                     | 28.63                    | 19.45                    | 9.17                               |
| 1862, . . . . .     | 1,245,328   | 11,014     | 32,275  | 22,974  | 9,301                         | 17.69                     | 25.92                    | 18.45                    | 7.47                               |
| 1863, . . . . .     | 1,252,521   | 10,873     | 30,314  | 27,751  | 2,563                         | 17.36                     | 24.20                    | 22.15                    | 2.05                               |
| 1864, . . . . .     | 1,259,756   | 12,513     | 30,449  | 28,763  | 1,686                         | 19.87                     | 24.17                    | 22.83                    | 1.35                               |
| 1865, . . . . .     | 1,267,031   | 13,051     | 30,249  | 26,152  | 4,097                         | 20.60                     | 23.87                    | 20.64                    | 3.23                               |
| 1866, . . . . .     | 1,302,992   | 14,428     | 34,085  | 23,637  | 10,448                        | 22.14                     | 26.16                    | 18.14                    | 8.02                               |
| 1867, . . . . .     | 1,339,976   | 14,451     | 35,062  | 22,773  | 12,289                        | 21.57                     | 26.17                    | 17.00                    | 9.17                               |
| 1868, . . . . .     | 1,378,010   | 13,856     | 36,193  | 25,603  | 10,590                        | 20.12                     | 26.26                    | 18.58                    | 7.68                               |
| 1869, . . . . .     | 1,417,125   | 14,826     | 36,141  | 26,054  | 10,087                        | 20.92                     | 25.50                    | 18.39                    | 7.12                               |
| 1870, . . . . .     | 1,457,351   | 14,721     | 38,259  | 27,329  | 10,930                        | 20.20                     | 26.25                    | 18.75                    | 7.50                               |
| 1871, . . . . .     | 1,494,334   | 15,746     | 39,791  | 27,943  | 11,848                        | 21.08                     | 26.63                    | 18.70                    | 7.93                               |
| 1872, . . . . .     | 1,532,258   | 16,142     | 43,235  | 35,019  | 8,216                         | 21.08                     | 28.22                    | 22.85                    | 5.37                               |
| 1873, . . . . .     | 1,571,146   | 16,437     | 44,481  | 33,912  | 10,569                        | 20.92                     | 28.31                    | 21.58                    | 6.73                               |
| 1874, . . . . .     | 1,611,922   | 15,864     | 45,631  | 31,887  | 13,744                        | 19.32                     | 28.32                    | 19.79                    | 8.53                               |
| 1875, . . . . .     | 1,651,912   | 13,663     | 43,996  | 34,978  | 9,018                         | 16.54                     | 26.63                    | 21.17                    | 5.46                               |
| 1876, . . . . .     | 1,677,351   | 12,749     | 42,149  | 33,186  | 8,963                         | 15.20                     | 25.13                    | 19.78                    | 5.34                               |
| 1877, . . . . .     | 1,703,182   | 12,758     | 41,850  | 31,342  | 10,508                        | 14.98                     | 24.57                    | 18.40                    | 6.17                               |
| 1878, . . . . .     | 1,729,410   | 12,893     | 41,238  | 31,303  | 9,935                         | 14.91                     | 23.84                    | 18.10                    | 5.74                               |
| 1879, . . . . .     | 1,756,042   | 13,802     | 40,295  | 31,801  | 8,494                         | 15.72                     | 22.94                    | 18.11                    | 4.83                               |
| 1880, . . . . .     | 1,783,085   | 15,538     | 44,217  | 35,292  | 8,925                         | 17.42                     | 24.80                    | 19.79                    | 5.01                               |
| 1881, . . . . .     | 1,813,818   | 16,768     | 45,220  | 36,458  | 8,762                         | 18.49                     | 24.93                    | 20.10                    | 4.83                               |
| 1882, . . . . .     | 1,845,081   | 17,084     | 45,670  | 36,785  | 8,885                         | 19.17                     | 24.75                    | 19.93                    | 4.82                               |
| 1883, . . . . .     | 1,876,883   | 18,194     | 47,285  | 37,748  | 9,537                         | 19.38                     | 25.19                    | 20.11                    | 5.08                               |
| 1884, . . . . .     | 1,909,233   | 17,333     | 48,615  | 38,990  | 9,625                         | 18.16                     | 25.46                    | 19.38                    | 6.08                               |
| 1885, . . . . .     | 1,942,141   | 17,052     | 48,790  | 38,094  | 10,696                        | 17.56                     | 25.12                    | 19.61                    | 5.51                               |
| 1886, . . . . .     | 1,998,174   | 18,018     | 50,788  | 37,244  | 13,544                        | 18.04                     | 25.41                    | 18.64                    | 6.77                               |
| 1887, . . . . .     | 2,035,823   | 19,533     | 53,174  | 40,763  | 12,411                        | 19.00                     | 25.87                    | 19.85                    | 6.04                               |
| 1888, . . . . .     | 2,115,136   | 19,739     | 54,893  | 42,097  | 12,796                        | 18.66                     | 25.95                    | 19.90                    | 6.05                               |
| 1889, . . . . .     | 2,176,159   | 20,307     | 57,075  | 41,777  | 15,298                        | 18.74                     | 26.23                    | 19.20                    | 7.03                               |
| 1890, . . . . .     | 2,236,943   | 20,838     | 57,777  | 43,528  | 14,249                        | 18.62                     | 25.81                    | 19.44                    | 6.37                               |
| 1891, . . . . .     | 2,288,911   | 21,675     | 63,004  | 45,185  | 17,819                        | 18.94                     | 27.53                    | 19.74                    | 7.79                               |
| 1892, . . . . .     | 2,339,993   | 22,507     | 65,524  | 48,762  | 17,062                        | 19.24                     | 28.13                    | 20.84                    | 7.29                               |
| 1893, . . . . .     | 2,392,216   | 22,814     | 67,192  | 49,084  | 18,108                        | 19.07                     | 28.09                    | 20.52                    | 7.57                               |
| 1894, . . . . .     | 2,445,604   | 20,619     | 66,936  | 46,791  | 20,145                        | 16.86                     | 27.37                    | 19.14                    | 8.24                               |
| 1895, . . . . .     | 2,507,183   | -          | -       | -       | -                             | -                         | -                        | -                        | -                                  |

\* The statistics of the first eight years of registration are for the years ending with April 30 of each year.

† The second line of statistics for 1848 is for the eight months ending Dec. 31, 1848.

‡ The statistics for 1849 and for each of the following years are for the calendar years ending Dec. 31.

estimates of inter-censal years in the table on the foregoing are made in accordance with the rule recommended by Dr. (the geometric rate of increase).

the vital statistics of the first seven years of registration (1842-48), as well as the returns of marriages for 1849, must be regarded as generally defective; many of the returns from Suffolk County for this period are wanting, together with those of some of the small towns.

From the year 1849 onward the omissions probably constitute but a small percentage only of the total registration.

The figures for the population of census years are given in bold

#### INTERSTATE AND INTERNATIONAL VITAL STATISTICS.

The following table presents briefly the marriage, birth and death statistics of the New England States for a period of twenty years, or as long a time as they were accessible.

The statistics of the principal European countries are also presented, the data from this portion of the table being mostly obtained from the report of the registrar general of England for 1894.



TABLE 2. — *Summary of the Vital Statistics of Principal Countries for Twenty Years, and for 1893 and 1894, together with those of the New England States.*

| STATES AND COUNTRIES.        | TWENTY YEARS—1871-1890. |             |             |                                       | 1893.          |             |             |                                       | 1894.          |             |             |                                       |
|------------------------------|-------------------------|-------------|-------------|---------------------------------------|----------------|-------------|-------------|---------------------------------------|----------------|-------------|-------------|---------------------------------------|
|                              | Marriage Rate.          | Birth Rate. | Death Rate. | Excess of Birth Rate over Death Rate. | Marriage Rate. | Birth Rate. | Death Rate. | Excess of Birth Rate over Death Rate. | Marriage Rate. | Birth Rate. | Death Rate. | Excess of Birth Rate over Death Rate. |
|                              |                         |             |             |                                       |                |             |             |                                       |                |             |             |                                       |
| Massachusetts, . . . . .     | 18.1                    | 25.7        | 19.7        | 6.0                                   | 18.7           | 27.5        | 20.1        | 7.4                                   | 16.9           | 27.4        | 19.1        | 8.3                                   |
| Maine, . . . . .             | -                       | -           | -           | -                                     | 17.5           | 21.0        | 16.8        | 4.2                                   | -              | -           | -           | -                                     |
| New Hampshire, . . . . .     | 18.6                    | 18.0*       | 18.9        | -                                     | 21.2           | 20.5*       | 19.9        | -                                     | -              | -           | -           | -                                     |
| Vermont, . . . . .           | 15.6                    | 20.2        | 15.1        | 5.1                                   | 17.7           | 20.5        | 16.1        | 4.4                                   | 17.0           | 20.5        | 15.6        | 4.9                                   |
| Rhode Island, . . . . .      | 18.7                    | 23.7        | 18.0        | 5.7                                   | 19.0           | 25.8        | 20.0        | 5.8                                   | 17.1           | 25.1        | 18.7        | 6.4                                   |
| Connecticut, . . . . .       | 16.0                    | 23.6        | 17.1        | 6.5                                   | 16.4           | 24.7        | 18.9        | 5.8                                   | 14.2           | 24.9        | 16.8        | 8.1                                   |
| NEW ENGLAND, . . . . .       | -                       | -           | -           | -                                     | 18.5           | 25.3        | 19.4        | 5.9                                   | 16.4†          | 25.9†       | 18.4†       | 7.5†                                  |
| England and Wales, . . . . . | 15.6                    | 34.0        | 20.3        | 13.7                                  | 14.7           | 30.8        | 19.2        | 11.6                                  | 15.1           | 29.6        | 16.6        | 13.0                                  |
| Scotland, . . . . .          | 13.9                    | 33.6        | 20.4        | 13.2                                  | 13.2           | 31.0        | 19.4        | 11.6                                  | 13.4           | 30.1        | 17.2        | 12.9                                  |
| Ireland, . . . . .           | 9.0                     | 24.9        | 18.0        | 6.9                                   | 9.4            | 23.0        | 17.9        | 5.1                                   | 9.4            | 22.9        | 18.2        | 4.7                                   |
| Italy, . . . . .             | 15.6                    | 37.3        | 28.6        | 8.7                                   | 14.7           | 36.6        | 25.3        | 11.3                                  | 15.0           | 35.7        | 25.1        | 10.6                                  |
| Denmark, . . . . .           | 15.2                    | 31.7        | 19.0        | 12.7                                  | 14.1           | 30.6        | 18.9        | 11.7                                  | 13.9           | 30.2        | 17.5        | 12.7                                  |
| Norway, . . . . .            | 13.7                    | 30.7        | 16.9        | 13.8                                  | 12.8           | 30.7        | 16.4        | 14.3                                  | 12.8           | 29.7        | 16.9        | 12.8                                  |
| Sweden, . . . . .            | 13.1                    | 29.8        | 17.6        | 12.2                                  | 11.3           | 27.4        | 16.8        | 10.6                                  | 11.5           | 27.1        | 16.4        | 10.7                                  |
| Austria, . . . . .           | 16.3                    | 38.6        | 30.6        | 8.0                                   | 15.9           | 37.9        | 27.1        | 10.8                                  | -              | -           | -           | -                                     |
| Hungary,† . . . . .          | 19.1                    | 44.0        | 33.7        | 10.3                                  | 18.6           | 42.5        | 31.1        | 11.4                                  | -              | -           | -           | -                                     |
| Switzerland, . . . . .       | 14.7                    | 29.4        | 22.1        | 7.3                                   | 14.7           | 28.5        | 20.5        | 8.0                                   | 14.9           | 28.2        | 20.7        | 7.5                                   |
| German Empire,‡ . . . . .    | 16.4                    | 38.1        | 26.0        | 12.1                                  | 15.8           | 36.7        | 24.6        | 12.1                                  | 15.9           | 35.8        | 22.3        | 13.5                                  |
| Holland, . . . . .           | 15.1                    | 35.2        | 22.6        | 12.6                                  | 14.6           | 33.8        | 19.2        | 14.6                                  | 14.4           | 32.7        | 18.5        | 14.2                                  |
| Belgium, . . . . .           | 14.2                    | 31.0        | 21.4        | 9.6                                   | 15.2           | 29.5        | 20.3        | 9.2                                   | 15.1           | 29.0        | 18.6        | 10.4                                  |
| France, . . . . .            | 15.4                    | 24.6        | 22.8        | 1.8                                   | 15.1           | 22.9        | 22.8        | 0.1                                   | -              | -           | -           | -                                     |
| Japan,   . . . . .           | -                       | 27.7        | 20.5        | 7.2                                   | -              | -           | -           | -                                     | -              | -           | -           | -                                     |

\* Seven years. Registration of births said to be defective.

† Except Maine and New Hampshire.

‡ Fifteen years.

§ Nineteen years.

|| Ten years (1883-92).

# MARRIAGES.

The whole number of marriages registered in Massachusetts in 1890 was 20,619. This number was equivalent to a rate of 16.86 per 1,000 of the estimated population (persons married), or 8.43 marriages in each thousand. It was also equivalent to one marriage for each 119 persons.

The number of marriages was less by 2,195 than those of 1893. The marriages and marriage rates for the ten years (1885-94) are as follows:—

TABLE 3.—*Marriages and Marriage Rates, 1885-94.*

| YEARS. | Marriages. | Marriage Rates. |
|--------|------------|-----------------|
| 1885   | 17,052     | 17.6            |
| 1886   | 18,018     | 18.0            |
| 1887   | 19,533     | 19.0            |
| 1888   | 19,739     | 18.7            |
| 1889   | 20,397     | 18.7            |
| 1890   | 20,838     | 18.6            |
| 1891   | 21,675     | 18.8            |
| 1892   | 22,507     | 20.0            |
| 1893   | 22,814     | 18.7            |
| 1894   | 20,619     | 16.9            |
| Total, | 203,192    | —               |
| Mean,  | —          | 18.5            |

The marriage rate was less than that of any year since 1879. The rate of the ten-year period (1885-94) was 18.5.

*Marriages by Counties.*—The number of marriages in each county during the four years, 1891, 1892, 1893 and 1894, together with the marriage rates for 1890, were as follows:—

TABLE 4. — *Marriages by Counties, 1891-94, and Marriage Rates, 1890.*

|                       | 1891.  | 1892.  | 1893.  | 1894.  | Marriage Rates, 1890. |
|-----------------------|--------|--------|--------|--------|-----------------------|
| THE STATE, . . . . .  | 21,675 | 22,507 | 22,814 | 20,619 | 18.62                 |
| Barnstable, . . . . . | 245    | 221    | 209    | 214    | 16.78                 |
| Berkshire, . . . . .  | 605    | 625    | 618    | 562    | 15.12                 |
| Bristol, . . . . .    | 1,850  | 2,045  | 2,089  | 1,825  | 20.22                 |
| Dukes, . . . . .      | 33     | 38     | 39     | 27     | 18.54                 |
| Essex, . . . . .      | 2,905  | 2,899  | 3,108  | 2,691  | 18.48                 |
| Franklin, . . . . .   | 310    | 331    | 335    | 284    | 14.76                 |
| Hampden, . . . . .    | 1,388  | 1,479  | 1,401  | 1,270  | 17.64                 |
| Hampshire, . . . . .  | 448    | 438    | 410    | 414    | 16.26                 |
| Middlesex, . . . . .  | 4,083  | 4,259  | 4,373  | 3,721  | 17.80                 |
| Nantucket, . . . . .  | 16     | 28     | 21     | 16     | 11.00                 |
| Norfolk, . . . . .    | 944    | 956    | 976    | 830    | 15.76                 |
| Plymouth, . . . . .   | 798    | 804    | 840    | 717    | 17.32                 |
| Suffolk, . . . . .    | 5,574  | 5,708  | 5,745  | 5,809  | 21.94                 |
| Worcester, . . . . .  | 2,476  | 2,676  | 2,655  | 2,239  | 17.70                 |

*Age.* — The average ages at marriage of all men and women married, and of men and women married for the first time, were as follows : —

TABLE 5. — *Average Ages at Marriage, 1891-94, expressed in Years and Fractions of a Year.*

|                 | Average Age of All Bridesgrooms. | Average Age of All Brides. | Average Age of Men Marrying for the First Time. | Average Age of Women Marrying for the First time. |
|-----------------|----------------------------------|----------------------------|-------------------------------------------------|---------------------------------------------------|
| 1891, . . . . . | 28.85                            | 25.53                      | 26.82                                           | 24.28                                             |
| 1892, . . . . . | 28.85                            | 25.37                      | 26.76                                           | 24.24                                             |
| 1893, . . . . . | 28.90                            | 25.47                      | 26.86                                           | 24.40                                             |
| 1894, . . . . . | 29.10                            | 25.59                      | 26.93                                           | 24.39                                             |

Three hundred and seventy-seven men and 3,199 women married when under twenty years of age, and 69 men and 8 women married when over seventy. Of the former class there were 23 women aged fifteen, 6 aged fourteen and 1 of thirteen years; all the men were over fifteen years of age.

The mean age of men at marriage in England in 1894 was 28.4 years and that of women was 26.1 years.

ons.—The marriages by calendar months were as follows for

TABLE 6.—*Marriages by Months (1894).*

|        | Marriages. | Monthly Ratio compared with a Standard of 100.* |               | Marriages. | Monthly Ratio compared with a Standard of 100.* |
|--------|------------|-------------------------------------------------|---------------|------------|-------------------------------------------------|
| . . .  | 1,634      | 93.3                                            | September, .  | 2,005      | 118.3                                           |
| y, . . | 1,088      | 68.8                                            | October, . .  | 2,377      | 135.8                                           |
| . . .  | 1,053      | 60.1                                            | November, .   | 2,376      | 140.2                                           |
| . . .  | 1,867      | 110.1                                           | December, . . | 1,544      | 88.1                                            |
| . . .  | 1,405      | 80.2                                            |               |            |                                                 |
| . . .  | 2,433      | 143.5                                           | Total, . .    | 20,619     | —                                               |
| . . .  | 1,437      | 82.1                                            |               |            |                                                 |
| . . .  | 1,400      | 79.9                                            | Mean, . .     | —          | 100.0                                           |

is column the inaccuracies due to the unequal lengths of the months are eliminated by the daily number of marriages in each month and comparing this number with a daily of 100 for the whole year.

mean daily number of marriages for the year was 56.5.

greatest daily number of marriages occurred in June, October November, and the least in March, February and August.

percentages of marriages in each quarter were as follows: quarter 18.31 per cent., second quarter 27.67, third quarter fourth quarter 30.54.

### BIRTHS.

whole number of living births registered in Massachusetts in 1894 was 66,936, which was larger than that of any previous year since the beginning of registration. The birth rate was 27.4 per cent. of the estimated living population, which was less than that of 1891, 1892 or 1893, but greater than that of any previous year since 1874.

births and birth rates for the ten years 1885–94 were as follows:—

TABLE 7.—*Births and Birth Rates, Ten Years, 1885–94.*

| YEARS. | Births. | Birth Rates. | YEARS.      | Births. | Birth Rates. |
|--------|---------|--------------|-------------|---------|--------------|
| . . .  | 48,790  | 25.1         | 1892, . . . | 65,824  | 28.1         |
| . . .  | 50,788  | 25.4         | 1893, . . . | 67,192  | 28.1         |
| . . .  | 53,174  | 25.9         | 1894, . . . | 66,936  | 27.4         |
| . . .  | 54,893  | 25.9         |             |         |              |
| . . .  | 57,075  | 26.2         | Total, . .  | 585,453 | —            |
| . . .  | 57,777  | 25.8         |             |         |              |
| . . .  | 63,004  | 27.5         | Mean, . .   | —       | 26.6         |

*Sex.*—Of the whole number of living children born in 1894, 34,338 were males and 32,575 were females, indicating a ratio of 1,054 males to 1,000 females, that of the period of forty-two years (1853-94) having been 1,055 males to 1,000 females.

The following were the numbers by sexes for the four years 1891-94 and for the forty-two years 1853-94:—

TABLE 8.—*Births by Sexes, 1853-94, 1891, 1892, 1893 and 1894.*

| YEARS.             | Males.  | Females. | Males to 1,000 Females. |
|--------------------|---------|----------|-------------------------|
| 1853-94, . . . . . | 920,067 | 871,781  | 1,055                   |
| 1891, . . . . .    | 32,532  | 30,434   | 1,069                   |
| 1892, . . . . .    | 33,758  | 31,951   | 1,057                   |
| 1893, . . . . .    | 34,328  | 32,829   | 1,046                   |
| 1894, . . . . .    | 34,338  | 32,575   | 1,054                   |

The ratio of male to female births in England for the fifty-seven years ending with 1894 was 1,042 males to 1,000 females.

*Seasons.*—The number of births in each month and the monthly ratio reduced to a standard of 100 was as follows:—

TABLE 9.—*Births by Months (1894).*

| MONTHS.              | Births. | Monthly Ratio reduced to a Standard of 100. | MONTHS.             | Births. | Monthly Ratio reduced to a Standard of 100. |
|----------------------|---------|---------------------------------------------|---------------------|---------|---------------------------------------------|
| January, . . . . .   | 5,500   | 96.7                                        | October, . . . . .  | 5,530   | 97.3                                        |
| February, . . . . .  | 4,978   | 96.9                                        | November, . . . . . | 5,579   | 101.4                                       |
| March, . . . . .     | 5,681   | 99.9                                        | December, . . . . . | 5,907   | 103.9                                       |
| April, . . . . .     | 5,529   | 100.5                                       | Unknown, . . . . .  | 3       | —                                           |
| May, . . . . .       | 5,472   | 96.2                                        | Total, . . . . .    | 66,936  | —                                           |
| June, . . . . .      | 5,506   | 100.1                                       | Mean, . . . . .     | —       | 100.0                                       |
| July, . . . . .      | 5,999   | 105.5                                       |                     |         |                                             |
| August, . . . . .    | 5,794   | 101.9                                       |                     |         |                                             |
| September, . . . . . | 5,458   | 99.2                                        |                     |         |                                             |

The mean daily number of births was 183.4, and from the foregoing table it appears that the highest daily number of births occurred in July and December, and the least in May and January.

The highest quarterly percentage of births registered was in the third quarter of the year, and the same may be said of the births in each year of the previous twenty-year period, except 1878, in which the greatest number was in the fourth quarter.

*Births by Counties.* — The numbers of living births in each county during the four years 1891, 1892, 1893 and 1894, together with the birth rates for 1890, were as follows: —

TABLE 10. — *Births by Counties, 1891-94, and Birth Rates, 1890.*

|                       | 1891.  | 1892.  | 1893.  | 1894.  | Birth Rates,<br>1890. |
|-----------------------|--------|--------|--------|--------|-----------------------|
| STATE, . . . . .      | 63,004 | 65,824 | 67,192 | 66,936 | 25.81                 |
| Barnstable, . . . . . | 530    | 546    | 516    | 536    | 16.38                 |
| Berkshire, . . . . .  | 2,179  | 2,083  | 2,283  | 2,248  | 26.32                 |
| Bristol, . . . . .    | 5,436  | 5,924  | 6,200  | 6,188  | 26.58                 |
| Dukes, . . . . .      | 56     | 71     | 73     | 65     | 18.08                 |
| Essex, . . . . .      | 7,804  | 7,784  | 8,392  | 8,177  | 23.68                 |
| Franklin, . . . . .   | 813    | 898    | 908    | 912    | 19.68                 |
| Hampden, . . . . .    | 4,611  | 4,708  | 4,864  | 4,589  | 30.47                 |
| Hampshire, . . . . .  | 1,126  | 1,229  | 1,194  | 1,194  | 20.90                 |
| Middlesex, . . . . .  | 12,347 | 12,879 | 13,197 | 13,246 | 25.85                 |
| Nantucket, . . . . .  | 52     | 50     | 55     | 55     | 15.30                 |
| Norfolk, . . . . .    | 2,947  | 2,956  | 3,132  | 3,105  | 22.78                 |
| Plymouth, . . . . .   | 1,905  | 1,946  | 2,144  | 1,976  | 18.96                 |
| Suffolk, . . . . .    | 15,227 | 16,542 | 15,538 | 16,408 | 28.98                 |
| Worcester, . . . . .  | 7,971  | 8,208  | 8,696  | 8,237  | 26.07                 |

*Illegitimacy.* — The number of illegitimate births registered in 1894 was 564. The statistics of the years 1891, 1892, 1893 and 1894, with the ratios per 1,000 of living births, are as follows: —

TABLE 11. — *Illegitimate Births.*

| YEARS.          |       | Ratio per<br>1,000 Births. | YEARS.          |     | Ratio per<br>1,000 Births. |
|-----------------|-------|----------------------------|-----------------|-----|----------------------------|
| 1891, . . . . . | 1,078 | 17.1                       | 1893, . . . . . | 540 | 10.2*                      |
| 1892, . . . . . | 990   | 15.0                       | 1894, . . . . . | 564 | 10.9*                      |

The illegitimate birth rates of 1893 and 1894 are estimated for the whole State, except the City of Boston.

TABLE 12 — *Illegitimate Births by Counties (1891, 1892, 1893 and 1894).*

| THE STATE.      | Barnstable. | Berkshire. | Bristol. | Dukes. | Essex. | Franklin. | Hampden. | Hampshire. | Middlesex. | Nantucket. | Norfolk. | Plymouth. | Suffolk. | Worcester. |
|-----------------|-------------|------------|----------|--------|--------|-----------|----------|------------|------------|------------|----------|-----------|----------|------------|
| 1891, . . . . . | 11          | 21         | 50       | —      | 79     | 5         | 44       | 7          | 121        | 1          | 22       | 14        | 654      | 49         |
| 1892, . . . . . | 8           | 27         | 65       | 3      | 81     | 10        | 62       | 12         | 171        | 3          | 21       | 13        | 445      | 69         |
| 1893, . . . . . | 10          | 26         | 59       | 1      | 94     | 10        | 46       | 8          | 149        | 2          | 23       | 11        | 14       | 87         |
| 1894, . . . . . | 6           | 33         | 53       | 1      | 100    | 7         | 52       | 22         | 168        | 2          | 25       | 15        | 14       | 66         |

In the foregoing table are presented the statistics of illegitimate births by counties for the four years ending with 1894. The special point worthy of note in this table is the apparently defective record of Suffolk County for the years 1893 and 1894.

*Plural Births.*—In 1894 there were registered 654 cases of plural births, being in the ratio of 9.8 per 1,000 births. The number of children born was 1,316, of which number 1,292 were twins and 24 were triplets. Of the whole number, 658 were males and 657 were females.

The statistics for the four years 1891, 1892, 1893 and 1894 were as follows :—

TABLE 13.

| YEARS.                          | Cases of Twins. | Cases of Triplets. | Cases of Quad-ruplets. | Numbers of Living Births to one Case of Twins. | Number of Living Births to one Case of Triplets. |
|---------------------------------|-----------------|--------------------|------------------------|------------------------------------------------|--------------------------------------------------|
| 1891, . . . . .                 | 616             | 7                  | 1                      | 102                                            | 9,000                                            |
| 1892, . . . . .                 | 572             | 8                  | —                      | 115                                            | 8,228                                            |
| 1893, . . . . .                 | 610             | 9                  | —                      | 110                                            | 7,466                                            |
| 1894, . . . . .                 | 654             | 8                  | —                      | 102                                            | 8,367                                            |
| Total, 4 years, . . . . .       | 2,452           | 32                 | 1                      | —                                              | —                                                |
| Mean, . . . . .                 | —               | —                  | —                      | 107                                            | 8,217                                            |
| Total cases, 1875-94, . . . . . | 9,101           | 103                | 1                      | —                                              | —                                                |
| Mean, . . . . .                 | —               | —                  | —                      | 113                                            | 9,961                                            |

There has been a notable increase in the number and ratio of cases of triplet births in the past seven years, from 1 in 27,446 in 1888 to 1 in 8,367 in 1894.

*Still-births.*—The total number of still-births registered in 1894 was 2,353, the number for the two preceding years being 2,222 in 1892 and 2,444 in 1893.

The following are the statistics relative to the sexes of the still-born for 1894 and for the period 1853 to 1894, forty-two years :—

|                                                                             | 1894. | 1853-94. |
|-----------------------------------------------------------------------------|-------|----------|
| Total number of the still-born, . . . . .                                   | 2,353 | 55,788   |
| Males, . . . . .                                                            | 1,424 | 30,941   |
| Females, . . . . .                                                          | 854   | 20,768   |
| Not stated, . . . . .                                                       | 75    | 4,079    |
| Ratio of males to 1,000 females, among those whose sex was known, . . . . . | 1,667 | 1,490    |

## DEATHS.

mortality statistics surpass all other vital statistics in importance, whether they are considered from a social, an actuarial or a sanitary standpoint." — NEWSHOLME.

The number of deaths registered in 1894 was 46,791; this was more than those of either 1892 or 1893, but greater than those of the previous years.

The death rate per 1,000 of the estimated living population was 19.70, that of the decade ending with 1894 having been 19.70.

The following are the deaths and death rates for the ten-year period 1885-94:—

TABLE 14.

| YEARS. | Deaths. | Death Rates. | YEARS.       | Deaths. | Death Rates. |
|--------|---------|--------------|--------------|---------|--------------|
| . . .  | 38,094  | 19.6         | 1892, . . .  | 48,762  | 20.8         |
| . . .  | 37,244  | 18.6         | 1893, . . .  | 49,084  | 20.5         |
| . . .  | 40,763  | 19.8         | 1894, . . .  | 46,791  | 19.1         |
| . . .  | 42,097  | 19.9         |              |         |              |
| . . .  | 41,777  | 19.2         | Total, . . . | 433,325 | —            |
| . . .  | 43,528  | 19.4         | Mean, . . .  | —       | 19.70        |
| . . .  | 45,185  | 19.7         |              |         |              |

*Deaths by Sexes.*—The number of deaths of males recorded in 1894 was 23,788 and that of females was 23,003. Estimating the proportion of the sexes upon the same basis as in 1890, the death rates of the sexes were 20.02 per 1,000 for males and 18.29 for females.

TABLE 15. — *Mortality of the Sexes, Census Years and 1894.*

| YEARS. | Deaths of Males. | Deaths of Females. | Death Rate of Males. | Death Rate of Females. | Deaths of Males to 1,000 Deaths of Females in Equal Numbers Living. |
|--------|------------------|--------------------|----------------------|------------------------|---------------------------------------------------------------------|
| . . .  | 11,444           | 11,547             | 19.3                 | 18.4                   | 1,048                                                               |
| . . .  | 13,085           | 13,024             | 21.7                 | 19.6                   | 1,107                                                               |
| . . .  | 13,699           | 13,598             | 19.5                 | 18.6                   | 1,048                                                               |
| . . .  | 17,329           | 17,619             | 21.8                 | 20.5                   | 1,063                                                               |
| . . .  | 17,426           | 17,852             | 20.3                 | 19.3                   | 1,052                                                               |
| . . .  | 18,889           | 19,205             | 20.2                 | 19.0                   | 1,063                                                               |
| . . .  | 21,767           | 21,761             | 20.0                 | 18.9                   | 1,058                                                               |
| . . .  | 23,788           | 23,003             | 20.0*                | 18.3*                  | 1,094*                                                              |

\* Estimated.



The disparity between the death rates of the sexes in Massachusetts was generally less than that of England, which was as 1,121 deaths of males to 1,000 deaths of females in equal numbers living for 1894, and as 1,103 to 1,000 for the whole period of registration (1838-94).

*Deaths by Seasons.*—In the following table are presented the statistics of deaths in Massachusetts by months and by sexes. For the purpose of presenting the seasonal mortality as fully and as clearly as possible, the method employed by Dr. Böckh of Berlin in his “Jahrbuch” has been followed. The exceedingly accurate and careful statistical methods adopted in Berlin give to the mortality statistics of that city a value which cannot be attained here under present American modes of collection of statistics. The figures in the following table may be taken as approximately correct, any errors that may exist being probably limited to the decimals only in columns 4, 5 and 6.

TABLE 16. — *Mortality by Months, Massachusetts (1894).*

| MONTHS.          | 1<br>Males. | 2<br>Females. | 3<br>Totals. | 4<br>Death Rate<br>per 1,000.<br>(Annual.) | 5<br>Monthly Mortality Reduced<br>to a Standard<br>of 100. | 6<br>Deaths per<br>Day. |
|------------------|-------------|---------------|--------------|--------------------------------------------|------------------------------------------------------------|-------------------------|
| January, . . .   | 2,333       | 2,198         | 4,531        | 21.9                                       | 114.0                                                      | 146.1                   |
| February, . . .  | 1,793       | 1,793         | 3,586        | 19.2                                       | 99.9                                                       | 128.1                   |
| March, . . .     | 1,903       | 1,949         | 3,852        | 18.7                                       | 97.0                                                       | 124.3                   |
| April, . . .     | 1,935       | 1,768         | 3,703        | 18.4                                       | 96.3                                                       | 123.4                   |
| May, . . .       | 1,831       | 1,745         | 3,576        | 17.2                                       | 90.0                                                       | 115.4                   |
| June, . . .      | 1,684       | 1,631         | 3,315        | 16.5                                       | 86.2                                                       | 110.5                   |
| July, . . .      | 2,450       | 2,338         | 4,788        | 22.9                                       | 120.5                                                      | 154.5                   |
| August, . . .    | 2,254       | 2,317         | 4,571        | 21.9                                       | 115.1                                                      | 147.5                   |
| September, . . . | 2,136       | 2,008         | 4,144        | 20.5                                       | 107.7                                                      | 138.1                   |
| October, . . .   | 1,872       | 1,831         | 3,703        | 17.6                                       | 93.2                                                       | 119.5                   |
| November, . . .  | 1,729       | 1,650         | 3,379        | 16.6                                       | 87.8                                                       | 112.6                   |
| December, . . .  | 1,868       | 1,775         | 3,643        | 17.3                                       | 91.6                                                       | 117.5                   |
|                  | 23,788      | 23,003        | 46,791       | 19.1                                       | 100.0                                                      | 128.2                   |

In the foregoing table, in the figures presented in columns 4 and 5 the inaccuracies due to the unequal length of the months have been eliminated by comparing the daily number of deaths in each month with the mean daily number for the year. In estimating the mortality rates given in column 4, a quarterly estimate has been adopted, based upon the rate of growth from 1890 to 1895, after the manner adopted by the registrar general of England in his weekly reports. By this table it appears that the months in which

test daily number of deaths occurred were July, August  
ary, and those which had the least were June, November

percentages of deaths in each quarter of the year were as

|                           |             |
|---------------------------|-------------|
| first quarter, . . . . .  | 25.6        |
| second quarter, . . . . . | 22.7        |
| third quarter, . . . . .  | 28.8        |
| fourth quarter, . . . . . | 22.9        |
|                           | <hr/> 100.0 |

*as by Counties.* — The number of deaths in each county during four years 1891, 1892, 1893 and 1894, together with the rates for 1890, were as follows, still-births being in every case excluded in this table: —

*— Deaths by Counties, 1891, 1892, 1893 and 1894, and Death Rates, 1890.*

|               | 1891.  | 1892.  | 1893.  | 1894.  | Death Rates,<br>1890. |
|---------------|--------|--------|--------|--------|-----------------------|
| RE, . . . . . | 45,185 | 48,762 | 49,084 | 46,791 | 19.4                  |
| e, . . . . .  | 615    | 640    | 592    | 559    | 19.4                  |
| , . . . .     | 1,486  | 1,560  | 1,505  | 1,391  | 18.2                  |
| . . . . .     | 4,109  | 4,867  | 4,608  | 4,416  | 20.3                  |
| . . . . .     | 109    | 99     | 115    | 108    | 25.4                  |
| . . . . .     | 5,916  | 6,272  | 6,064  | 5,584  | 20.0                  |
| . . . . .     | 699    | 766    | 654    | 608    | 15.8                  |
| , . . . .     | 2,644  | 3,181  | 2,999  | 2,616  | 19.6                  |
| e, . . . . .  | 969    | 1,051  | 1,037  | 910    | 18.5                  |
| ., . . . .    | 8,506  | 9,038  | 9,420  | 8,862  | 18.4                  |
| t, . . . . .  | 80     | 120    | 88     | 97     | 24.5                  |
| . . . . .     | 1,945  | 2,087  | 2,294  | 2,176  | 16.5                  |
| , . . . .     | 1,580  | 1,759  | 1,751  | 1,677  | 16.9                  |
| . . . . .     | 11,357 | 12,013 | 12,280 | 12,385 | 22.3                  |
| ., . . . .    | 5,220  | 5,809  | 5,677  | 5,402  | 17.8                  |

deaths in each county were less than those of 1893, with the  
n of Nantucket and Suffolk, in each of which there was an

#### CAUSES OF DEATH.

Following table is reproduced in this report for the sake of  
ty and comparison with similar tables of earlier years. Its  
nce, however, becomes of less importance in proportion to  
gress made in medical science and the classification of the  
f death.

TABLE 18.— *Causes of Death, by Classes, in Census Years and in 1891, 1892, 1893 and 1894. Ratio per 10,000 of the Population.*

| YEARS.                               | I.<br>Infectious<br>Diseases. | II.<br>Constitu-<br>tional<br>Diseases. | III.<br>Local<br>Diseases. | IV.<br>Devel-<br>opmental<br>Diseases.* | V.<br>Deaths<br>from<br>Violence. |
|--------------------------------------|-------------------------------|-----------------------------------------|----------------------------|-----------------------------------------|-----------------------------------|
| 1865, . . . . .                      | 64.87                         | 51.63                                   | 50.79                      | 26.48                                   | 7.34                              |
| 1870, . . . . .                      | 47.45                         | 49.30                                   | 51.85                      | 21.87                                   | 7.79                              |
| 1875, . . . . .                      | 58.96                         | 49.40                                   | 65.44                      | 23.16                                   | 8.61                              |
| 1880, . . . . .                      | 47.41                         | 45.89                                   | 73.73                      | 19.52                                   | 7.19                              |
| 1885, . . . . .                      | 36.74                         | 45.94                                   | 82.76                      | 20.65                                   | 7.48                              |
| 1890, . . . . .                      | 36.09                         | 41.14                                   | 87.13                      | 19.63                                   | 8.10                              |
| 1891, . . . . .                      | 36.10                         | 39.47                                   | 91.75                      | 20.18                                   | 8.10                              |
| 1892, . . . . .                      | 39.55                         | 39.84                                   | 97.74                      | 20.39                                   | 8.89                              |
| 1893, . . . . .                      | 36.53                         | 39.24                                   | 98.10                      | 19.78                                   | 9.25                              |
| 1894, . . . . .                      | 35.93                         | 37.94                                   | 88.47                      | 18.39                                   | 8.64                              |
| 1890-94 (Mean, five years, 1890-94), | 36.83                         | 39.50                                   | 92.68                      | 19.66                                   | 8.61                              |

\* Still-births excluded.

By this table it appears that very marked changes have taken place in the groups marked I., II. and III., the first two having notably decreased, while the third has quite as notably increased.

The following table presents the mortality from the ten most prominent causes of death in Massachusetts for the ten years 1885 to 1894, in the order of their prominence:—

TABLE 19.— *Mortality from Ten Prominent Causes. — 1885-1894.*

| CAUSES OF DEATH.        | Deaths,<br>1894. | 1885. | 1886. | 1887. | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. |
|-------------------------|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Consumption, . . .      | 5,463            | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| Brain diseases,* . .    | 5,113            | 2     | 3     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     |
| Pneumonia, . . . .      | 4,101            | 3     | 2     | 3     | 3     | 3     | 3     | 3     | 3     | 3     | 3     |
| Heart diseases, . .     | 3,621            | 4     | 4     | 4     | 4     | 4     | 4     | 4     | 4     | 4     | 4     |
| Cholera infantum, .     | 2,676            | 5     | 5     | 5     | 5     | 6     | 5     | 5     | 5     | 5     | 6     |
| Diphtheria and croup, . | 1,801            | 6     | 10    | 9     | 10    | 5     | 6     | 7     | 7     | 7     | 7     |
| Kidney diseases, . .    | 1,788            | 7     | 8     | 8     | 8     | 9     | 9     | 9     | 10    | 8     | 9     |
| Old age, . . . . .      | 1,669            | 8     | 6     | 6     | 6     | 7     | 7     | 6     | 6     | 6     | 5     |
| Bronchitis, . . . .     | 1,572            | 9     | 7     | 7     | 7     | 10    | 10    | 8     | 8     | 10    | 8     |
| Cancer, . . . . .       | 1,568            | 10    | 9     | 10    | 9     | 8     | 8     | 10    | 9     | 9     | 10    |

\* Including deaths certified as from apoplexy, paralysis, insanity, inflammatory diseases of the brain, and its membranes, and other brain diseases.

om this table it appears that consumption has maintained its ion at the head of the list for the whole decade, although very ly approached by pneumonia in 1893. Brain diseases held the id place from 1835 to 1892, but, for the year 1893, was dis- d by pneumonia. Diphtheria and croup attained the seventh for the first four years, and then rose to the fifth, but fell to ast place in 1891 and 1893, rising again to the sixth place in . Heart diseases and cholera infantum maintained, respectively, outh and fifth places for nearly the whole period.

*istics of Certain Causes and Groups of Causes of Death, Massa- chusetts, 1894.*

Table 20 are presented the principal statistics relative to the wing causes of death : —

|                       |                  |
|-----------------------|------------------|
| Small-pox.            | Pneumonia.       |
| Measles.              | Whooping-cough.  |
| Scarlet fever.        | Cancer.          |
| Diphtheria and croup. | Kidney diseases. |
| Typhoid fever.        | Heart diseases.  |
| Cholera infantum.     | Brain diseases.  |
| Consumption.          |                  |

data presented are the following : —  
er of deaths from each of the foregoing causes in each year for  
venty years (1875-94), . . . . .  
rate from each of the same causes per 10,000 of the living popu-  
ation for each year, . . . . .  
stage of the total mortality for each year, . . . . .  
xtals and means for the twenty-year period, . . . . .

} Table 20

TABLE 20. — STATISTICS OF CERTAIN CAUSES OF DEATH, MASSACHUSETTS, 1875-94.  
Deaths, and Ratios compared with Population and Mortality, from All Causes.

|                   | SMALL-POX. |                               |                                | MEASLES. |                               |                                | SCARLET FEVER. |                               |                                | DIPHTHERIA AND CROUP. |                               |                                | TYPHOID FEVER. |                               |                                | CHOLERA INFANTUM. |                               |                                | CONSUMPTION. |                               |                                |
|-------------------|------------|-------------------------------|--------------------------------|----------|-------------------------------|--------------------------------|----------------|-------------------------------|--------------------------------|-----------------------|-------------------------------|--------------------------------|----------------|-------------------------------|--------------------------------|-------------------|-------------------------------|--------------------------------|--------------|-------------------------------|--------------------------------|
|                   | Deaths.    | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.  | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.        | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.               | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.        | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.           | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.      | Death Rate per 10,000 Living. | Percentage of Total Mortality. |
| 1875,             | 34         | .2                            | .09                            | 233      | 1.4                           | 0.67                           | 1,684          | 10.2                          | 4.81                           | 1,880                 | 11.4                          | 6.31                           | 1,059          | 6.4                           | 3.02                           | 2,606             | 15.8                          | 7.45                           | 5,738        | 34.7                          | 16.40                          |
| 1876,             | 31         | .2                            | .09                            | 47       | 0.3                           | 0.14                           | 1,222          | 7.3                           | 3.08                           | 3,204                 | 19.6                          | 9.92                           | 881            | 5.3                           | 2.65                           | 2,087             | 12.4                          | 6.29                           | 5,327        | 32.2                          | 16.05                          |
| 1877,             | 24         | .14                           | .08                            | 135      | 0.8                           | 0.44                           | 467            | 2.7                           | 1.49                           | 3,178                 | 18.7                          | 10.14                          | 814            | 4.8                           | 2.59                           | 1,927             | 11.3                          | 6.15                           | 5,457        | 32.0                          | 17.41                          |
| 1878,             | 2          | .01                           | .01                            | 305      | 1.8                           | 0.97                           | 404            | 2.2                           | 1.29                           | 2,517                 | 14.6                          | 8.04                           | 679            | 3.9                           | 2.16                           | 1,573             | 9.1                           | 5.02                           | 5,334        | 30.8                          | 17.04                          |
| 1879,             | 7          | .04                           | .02                            | 19       | 0.1                           | 0.06                           | 880            | 4.8                           | 2.67                           | 2,293                 | 13.1                          | 7.21                           | 637            | 3.6                           | 2.00                           | 1,349             | 7.7                           | 4.24                           | 5,223        | 29.7                          | 16.42                          |
| 1880,             | 38         | .21                           | .11                            | 236      | 1.3                           | 0.67                           | 574            | 3.2                           | 1.63                           | 2,394                 | 13.4                          | 6.78                           | 882            | 4.9                           | 2.50                           | 2,118             | 11.9                          | 6.00                           | 5,494        | 30.8                          | 15.57                          |
| 1881,             | 47         | .25                           | .13                            | 230      | 1.3                           | 0.63                           | 397            | 2.2                           | 1.09                           | 2,383                 | 13.1                          | 6.54                           | 1,072          | 5.9                           | 2.94                           | 1,861             | 10.3                          | 5.10                           | 5,886        | 32.4                          | 16.14                          |
| 1882,             | 45         | .24                           | .12                            | 68       | 0.4                           | 0.18                           | 318            | 1.7                           | 0.86                           | 1,771                 | 9.6                           | 4.81                           | 1,079          | 5.8                           | 2.93                           | 2,150             | 11.7                          | 5.87                           | 5,865        | 31.8                          | 15.93                          |
| 1883,             | 5          | .03                           | .01                            | 321      | 1.7                           | 0.85                           | 575            | 3.1                           | 1.52                           | 1,621                 | 8.6                           | 4.29                           | 860            | 4.6                           | 2.28                           | 1,941             | 10.3                          | 5.14                           | 5,931        | 31.6                          | 15.71                          |
| 1884,             | 3          | .01                           | .01                            | 75       | 0.4                           | 0.20                           | 627            | 3.3                           | 1.69                           | 1,646                 | 8.6                           | 4.45                           | 875            | 4.6                           | 2.36                           | 2,081             | 10.9                          | 5.62                           | 5,798        | 30.4                          | 15.67                          |
| 1885,             | 19         | .10                           | .05                            | 313      | 1.6                           | 0.82                           | 587            | 3.0                           | 1.54                           | 1,523                 | 7.8                           | 3.98                           | 768            | 3.9                           | 2.02                           | 1,852             | 9.5                           | 4.86                           | 5,955        | 30.7                          | 15.63                          |
| 1886,             | -          | -                             | -                              | 130      | 0.6                           | 0.35                           | 331            | 1.7                           | 0.89                           | 1,558                 | 7.8                           | 4.18                           | 800            | 4.0                           | 2.15                           | 1,931             | 9.7                           | 5.18                           | 5,897        | 29.5                          | 15.83                          |
| 1887,             | 3          | .01                           | .007                           | 455      | 2.2                           | 1.12                           | 594            | 2.9                           | 1.46                           | 1,628                 | 7.9                           | 3.99                           | 922            | 4.5                           | 2.26                           | 2,131             | 10.4                          | 5.23                           | 5,871        | 28.6                          | 14.40                          |
| 1888,             | 8          | .04                           | .02                            | 219      | 1.0                           | 0.52                           | 504            | 2.4                           | 1.20                           | 1,831                 | 8.7                           | 4.35                           | 943            | 4.5                           | 2.34                           | 2,105             | 10.4                          | 5.21                           | 5,728        | 27.1                          | 13.61                          |
| 1889,             | 6          | .03                           | .01                            | 171      | 0.8                           | 0.41                           | 185            | 0.8                           | 0.44                           | 2,214                 | 10.2                          | 5.30                           | 891            | 4.1                           | 2.13                           | 2,156             | 9.9                           | 5.16                           | 5,581        | 25.7                          | 13.36                          |
| 1890,             | 1          | .004                          | .002                           | 114      | 0.5                           | 0.26                           | 196            | 0.9                           | 0.45                           | 1,626                 | 7.3                           | 3.74                           | 835            | 3.7                           | 1.92                           | 2,491             | 11.1                          | 5.72                           | 5,791        | 25.9                          | 13.31                          |
| 1891,             | 1          | .004                          | .002                           | 226      | 1.0                           | 0.52                           | 246            | 1.1                           | 0.54                           | 1,218                 | 5.8                           | 2.69                           | 821            | 3.6                           | 1.82                           | 2,771             | 12.1                          | 6.13                           | 5,484        | 24.0                          | 12.14                          |
| 1892,             | 2          | .01                           | .004                           | 88       | 0.4                           | 0.18                           | 669            | 2.9                           | 1.37                           | 1,455                 | 6.2                           | 2.98                           | 827            | 3.5                           | 1.69                           | 2,898             | 12.4                          | 5.64                           | 5,739        | 24.5                          | 11.77                          |
| 1893,             | 9          | .04                           | .02                            | 276      | 1.1                           | 0.56                           | 810            | 3.4                           | 1.65                           | 1,894                 | 6.8                           | 2.84                           | 750            | 3.1                           | 1.63                           | 2,704             | 11.8                          | 5.51                           | 5,527        | 23.1                          | 11.26                          |
| 1894,             | 33         | .13                           | .07                            | 98       | 0.4                           | 0.21                           | 640            | 2.6                           | 1.39                           | 1,801                 | 7.4                           | 3.85                           | 748            | 3.1                           | 1.60                           | 2,676             | 10.9                          | 5.72                           | 5,463        | 22.3                          | 11.67                          |
| Totals and means, | 318        | .08                           | .04                            | 3,769    | 0.9                           | 0.48                           | 11,889         | 5.0                           | 1.53                           | 39,225                | 9.9                           | 5.03                           | 17,143         | 4.3                           | 2.20                           | 43,507            | 10.9                          | 5.58                           | 113,089      | 28.5                          | 14.51                          |

## Deaths, and Ratios compared with Population and Mortality, from All Causes — Concluded.

|                   | PNEUMONIA. |                               |                                | WHOPING-COUGH. |                               |                                | CANCER. |                               |                                | KIDNEY DISEASES. |                               |                                | HEART DISEASES. |                               |                                | BRAIN DISEASES. |                               |                                |
|-------------------|------------|-------------------------------|--------------------------------|----------------|-------------------------------|--------------------------------|---------|-------------------------------|--------------------------------|------------------|-------------------------------|--------------------------------|-----------------|-------------------------------|--------------------------------|-----------------|-------------------------------|--------------------------------|
|                   | Deaths.    | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.        | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths. | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.          | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.         | Death Rate per 10,000 Living. | Percentage of Total Mortality. | Deaths.         | Death Rate per 10,000 Living. | Percentage of Total Mortality. |
| 1875, . . . . .   | 2,940      | 17.8                          | 8.40                           | 242            | 1.5                           | 0.69                           | 503     | 3.5                           | 1.69                           | 509              | 3.1                           | 1.45                           | 1,331           | 8.1                           | 3.80                           | 2,500           | 15.7                          | 7.40                           |
| 1876, . . . . .   | 2,447      | 14.6                          | 7.37                           | 192            | 1.1                           | 0.58                           | 657     | 3.9                           | 1.98                           | 488              | 2.9                           | 1.47                           | 1,335           | 8.0                           | 4.02                           | 2,507           | 14.9                          | 7.55                           |
| 1877, . . . . .   | 1,972      | 11.6                          | 6.29                           | 369            | 2.2                           | 1.18                           | 646     | 3.8                           | 2.06                           | 535              | 3.1                           | 1.71                           | 1,355           | 7.9                           | 4.32                           | 2,521           | 14.8                          | 8.04                           |
| 1878, . . . . .   | 2,171      | 12.6                          | 6.93                           | 409            | 2.3                           | 1.28                           | 807     | 4.7                           | 2.58                           | 615              | 3.6                           | 1.96                           | 1,442           | 8.4                           | 4.61                           | 2,778           | 16.1                          | 8.87                           |
| 1879, . . . . .   | 2,647      | 15.1                          | 8.32                           | 302            | 1.7                           | 0.95                           | 862     | 4.9                           | 2.71                           | 693              | 3.9                           | 2.18                           | 1,515           | 8.6                           | 4.76                           | 2,820           | 16.1                          | 8.87                           |
| 1880, . . . . .   | 3,076      | 17.3                          | 9.71                           | 290            | 1.3                           | 0.65                           | 928     | 5.2                           | 2.63                           | 698              | 3.9                           | 1.98                           | 1,726           | 9.7                           | 4.89                           | 3,210           | 18.0                          | 9.10                           |
| 1881, . . . . .   | 2,967      | 16.4                          | 8.14                           | 217            | 1.2                           | 0.69                           | 949     | 5.2                           | 2.60                           | 825              | 4.5                           | 2.27                           | 1,937           | 10.7                          | 5.31                           | 3,355           | 18.5                          | 9.20                           |
| 1882, . . . . .   | 2,932      | 15.9                          | 7.97                           | 265            | 1.4                           | 0.72                           | 987     | 5.3                           | 2.68                           | 877              | 4.7                           | 2.38                           | 2,025           | 11.0                          | 5.50                           | 3,393           | 18.4                          | 9.22                           |
| 1883, . . . . .   | 3,045      | 16.2                          | 8.07                           | 137            | 0.7                           | 0.36                           | 1,026   | 5.5                           | 2.72                           | 959              | 5.1                           | 2.54                           | 2,153           | 11.5                          | 5.70                           | 3,562           | 19.0                          | 9.44                           |
| 1884, . . . . .   | 2,646      | 13.9                          | 7.15                           | 410            | 2.1                           | 1.11                           | 1,060   | 5.6                           | 2.86                           | 1,000            | 5.2                           | 2.70                           | 2,117           | 11.1                          | 5.72                           | 3,669           | 19.2                          | 9.92                           |
| 1885, . . . . .   | 3,468      | 17.9                          | 9.10                           | 784            | 0.9                           | 0.48                           | 1,087   | 5.6                           | 2.85                           | 1,083            | 5.6                           | 2.86                           | 2,227           | 11.5                          | 5.85                           | 3,894           | 20.0                          | 10.22                          |
| 1886, . . . . .   | 2,856      | 14.2                          | 7.61                           | 271            | 1.4                           | 0.73                           | 1,104   | 5.5                           | 2.96                           | 1,135            | 5.7                           | 3.05                           | 2,325           | 11.6                          | 6.24                           | 3,844           | 19.2                          | 10.32                          |
| 1887, . . . . .   | 3,348      | 16.3                          | 8.21                           | 252            | 1.1                           | 0.57                           | 1,174   | 5.7                           | 2.88                           | 1,120            | 5.4                           | 2.75                           | 2,900           | 13.1                          | 6.60                           | 4,257           | 20.7                          | 10.44                          |
| 1888, . . . . .   | 3,716      | 17.6                          | 8.83                           | 245            | 1.2                           | 0.58                           | 1,375   | 6.0                           | 3.03                           | 1,318            | 6.2                           | 3.18                           | 3,061           | 14.5                          | 7.27                           | 4,522           | 21.4                          | 10.74                          |
| 1889, . . . . .   | 3,440      | 15.8                          | 8.23                           | 310            | 1.4                           | 0.74                           | 1,325   | 6.1                           | 3.17                           | 1,298            | 6.8                           | 3.01                           | 3,280           | 14.2                          | 7.85                           | 4,313           | 19.8                          | 10.32                          |
| 1890, . . . . .   | 4,038      | 18.0                          | 9.28                           | 363            | 1.6                           | 0.83                           | 1,387   | 6.2                           | 3.19                           | 1,273            | 5.7                           | 2.92                           | 3,417           | 15.3                          | 7.85                           | 4,389           | 19.6                          | 10.08                          |
| 1891, . . . . .   | 4,337      | 18.9                          | 9.60                           | 219            | 0.9                           | 0.48                           | 1,395   | 6.1                           | 3.09                           | 1,474            | 6.4                           | 3.26                           | 3,592           | 15.7                          | 7.95                           | 4,711           | 20.6                          | 10.42                          |
| 1892, . . . . .   | 5,020      | 21.5                          | 10.29                          | 248            | 1.1                           | 0.51                           | 1,402   | 6.0                           | 2.87                           | 1,535            | 6.6                           | 3.15                           | 3,733           | 16.0                          | 7.85                           | 5,036           | 21.5                          | 10.33                          |
| 1893, . . . . .   | 5,409      | 23.0                          | 11.20                          | 274            | 1.1                           | 0.66                           | 1,533   | 6.4                           | 3.12                           | 1,685            | 7.0                           | 3.43                           | 3,511           | 14.7                          | 7.15                           | 5,144           | 21.5                          | 10.48                          |
| 1894, . . . . .   | 4,101      | 16.7                          | 8.76                           | 435            | 1.8                           | 0.93                           | 1,568   | 6.4                           | 3.35                           | 1,721            | 7.0                           | 3.68                           | 3,432           | 14.0                          | 7.33                           | 4,995           | 20.4                          | 10.67                          |
| Totals and means, | 66,646     | 16.8                          | 8.55                           | 6,545          | 1.4                           | 0.71                           | 21,765  | 5.5                           | 2.79                           | 20,806           | 5.2                           | 2.79                           | 49,204          | 12.1                          | 6.19                           | 75,510          | 19.0                          | 9.69                           |

*Statistics of Certain Causes and Groups of Causes of Death for  
Twenty Years in Massachusetts (1875-94).*

Table 20 presents the statistics of certain destructive infectious and other diseases for a period of twenty years (1875-94), embracing the number of deaths, the death rate per 10,000 of the living population and the percentage of the total mortality for each year.

*Small-pox.*—The total number of deaths from this cause in 1894 was 33, a number greater than that of any year since 1882. It represented a death rate from this cause of .13 per 10,000 living and a percentage of .07 of the mortality from all causes.

*Measles.*—The deaths from measles was 98, or 178 less than those of the previous year and also less than those of any previous year since 1884, except 1892, when it was 88. The ratio of the living population was .4 and the percentage of the total mortality .21.

*Scarlet Fever.*—The deaths from scarlet fever were 649, which was less than those of either 1892 or 1893, but greater than those of any other previous years since 1876. The death rate from this cause was 2.6 per 10,000 of the living population and the percentage of the total mortality was 1.39.

*Diphtheria and Croup.*—The deaths from diphtheria and croup were 1,801, which was considerably greater than that of either of the four years 1890-93. The death rate per 10,000 living was 7.4 and the percentage of the total mortality was 3.85, both of which were less than the mean ratios for the twenty-year period (1875-94.)

*Typhoid Fever.*—The deaths from typhoid fever were 748, or less than those of any previous year since 1879. The ratio of the living population was 3.1 per 10,000 and the percentage of the total deaths was 1.6. Each of these ratios was less than the mean of the twenty-year period.

*Cholera Infantum.*—The number of deaths from this cause was 2,676. The death rate per 10,000 of the living population was 10.9 and the percentage of the total mortality 5.7. Each of these ratios being nearly identical with the mean for the twenty-year period.

*Consumption.*—The number of deaths from consumption was 5,463, or less than that of any year of the twenty-year period since 1879. The death rate per 10,000 of the living population and the percentage of the total deaths were each considerably less than

mean of the twenty-year period, and each of these ratios has usually diminished during the period.' (For fuller information relative to the mortality from this cause see last annual report.)

*Pneumonia*.—The deaths from this cause were 4,101. The ratio 10,000 living was 16.7 and the percentage of the total deaths 1.93, these ratios differing but little from the mean ratios of the twenty-year period.

*Whooping-cough*.—The deaths from whooping-cough in 1894 were 435. In absolute numbers, this mortality was greater than that of any year of the twenty-year period, but relatively it was exceeded the mortality from this cause in 1877, 1878 and 1884. The death rate per 10,000 living was 1.8 and the percentage of the total mortality was .93, the means of the twenty-year period being 1.8 and .93.

*Cancer*.—The deaths from cancer were 1,568, which number was greater than that of any previous year of the twenty-year period.

The death rate per 10,000 of the population was 6.4 as compared with a mean of 5.5 for the twenty years, and the percentage of the total mortality was 3.35, as compared with a mean of 2.79. The decrease in mortality from this cause was not so rapid during the last years as during the first half of the period.

*Kidney Diseases*.—The deaths from this group of causes were 211, which was greater than that of any year in the twenty-year period from the same causes. The death rate per 10,000 of living population was 7.0, as compared with a mean of 5.2, and the percentage of the total mortality was 3.68, as compared with a mean of 3.68.

*Heart Diseases*.—The deaths from this group of causes were 3,432, which number was less, absolutely, than that of either of the three preceding years. The death rate per 10,000 living was 14.0, as compared with a mean of 12.1, and was also less than that of either of the preceding six years. The percentage of the total mortality was 6.19, as compared with a mean of 6.19.

*Brain Diseases*.—The deaths from this group of causes in 1894 (including those from apoplexy, paralysis, cephalitis, insanity, softening of the brain and other brain diseases) were 4,995, which was less than those of either of the three preceding years. The death rate per 10,000 living from these causes was 20.4, as compared with a mean of 18.4 for the twenty-year period, and the percentage of the total



mortality was 10.7, as compared with 9.7 for the twenty-year period.

*Erysipelas.* — The deaths from this cause were 157, as compared with 251 in 1893.

*Puerperal Fever.* — The deaths from puerperal fever were 49, as compared with 46 in 1893. The deaths from other incidents of childbirth were 216.

*Malarial Fevers.* — The deaths registered as from these causes were 73.

*Syphilis.* — The deaths registered as from syphilis were 64, of which 37, or more than half, occurred in Suffolk County.

There were no deaths from hydrophobia, glanders, anthrax or trichinosis.

#### *Medical Examiner Returns.*

Separate returns of all deaths investigated by medical examiners are required by law. These comprise deaths by homicide, suicide, accidents and many deaths of a sudden or suspicious character which are referred to the medical examiners for investigation.

Of this class of deaths the whole number investigated in 1894 was 2,159, of which number 1,649 were deaths of males, 505 were deaths of females and the sex of 5 was unknown. The ratio of deaths of this class among males and females has shown but little change in the past ten years.

The whole number investigated was less than those of either 1892 or 1893, which were, respectively, 2,209 and 2,221. The mean annual number of deaths of this class investigated in the five-year period 1885-89 was 1,503, while that of the succeeding five-year period (1890-94) was 2,040, indicating a relative increase from 7.3 deaths per 10,000 of the living population investigated in the first period to 8.7 deaths per 10,000 in the second period.

*Homicide.* — The deaths from homicide were 68, as compared with 72 and 76, respectively, in 1892 and 1893. Comparing the two five-year periods 1885-89 and 1890-94 there was a slight increase, from an annual mean of .24 per 10,000 of the population in the former period to .27 per 10,000 in the latter.

*Suicide.* — The deaths from suicide were 270, while those of 1892 and 1893 were, respectively, 273 and 290. Comparing the two five-year periods, there was an increase from .87 per 10,000 of the living population in the former to 1.04 per 10,000 in the latter.

*Accident.*—The deaths from accident investigated were 975, as compared with 974 and 976 in 1892 and 1893. The mean annual ratio of deaths from accident investigated had also increased from 3.47 per 10,000 in the former to 3.97 in the latter period.

*Deaths from Natural and Unknown Causes.*—The deaths of this class investigated were 846, as compared with 890 in 1892 and 879 in 1893, while the mean annual ratio had increased from 2.72 per 10,000 in the former to 3.43 in the latter five-year period.



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# WATER SUPPLY AND SEWERAGE.

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## ADVICE TO CITIES AND TOWNS.

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## WATER SUPPLY AND SEWERAGE.\*

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ort required by the provisions of chapter 375 of the Acts of 1888, entitled in Act to protect the purity of inland waters, and to require consultation with the State Board of Health regarding the establishment of systems of water supply, drainage and sewerage.”]

he following report contains a summary of the work of the State Board of Health during the year 1895, under the provisions of chapter 375 of the Acts of 1888, including the substance of the replies given by the Board to those cities, towns, corporations and individuals which have applied to the Board for its advice relative to systems of water supply, drainage and sewerage, under the requirements of this act, together with a brief statement of the work done at the experiment station at Lawrence and in connection with the investigations of water supplies and rivers.

uring the year 1895 public water supplies were introduced in the towns of Barre, Longmeadow, Millbury, Monson and Rockport, and important additions to the sources of many existing works were made. At the end of the year 1895 all of the 31 cities in the Commonwealth and 123 towns out of a total of 322 were provided with a public water supply. The total population of the communities having a public water supply is 89.5 per cent. of the total population of the State. There are now but 4 towns which by the census of 1895 have a population exceeding 3,500 which are not provided with a public water supply. The names of these towns, with their respective populations, are as follows:—

|                               |                   |
|-------------------------------|-------------------|
| Town of Barnstable, . . . . . | Population, 4,055 |
| of North Andover, . . . . .   | “ 3,569           |
| of Blackstone, . . . . .      | “ 6,089           |
| of Winchendon, . . . . .      | “ 4,490           |

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The first pages of this report were contained in a report made to the Legislature Jan. 6, 1896 (see Document, No. 4). A portion of the report then made, relating to the work done at the Law-Experiment Station, is not reproduced, because a more complete account of the work done at this will be found in a subsequent part of this volume.

The rapid growth in the number of water supplies in the State in twenty years is indicated by a comparison of the statistics for 1895 with similar ones for 1875. At the end of the latter year 15 cities out of a total of 19 and 35 towns out of a total of 323 were provided with public water supplies, and the communities supplied contained 48.3 per cent. of the total population of the State.

The tendency in recent years toward municipal control of water supplies is indicated by a comparison of the number and population of municipalities supplied by private companies at the end of 1895 with the number similarly supplied at the end of 1890. At the end of 1895 all of the cities and 77 of the 123 towns in the State having a public water supply owned their works, while 46 towns were supplied by private companies. The total population of places supplied by private companies was 212,579, or 9.5 per cent. of the total population supplied. At the end of 1890 five of the 28 cities in the State having public water supplies and 50 of the 109 towns were supplied by private companies. The total population supplied from private works in 1890 was 318,319 or 16 per cent. of the total population supplied. There has been an increase of 17 in the number of works since 1890.

The flow of streams, as indicated by that of the Sudbury River, was less than the normal in January, February, March, May, June, August and September, slightly in excess of the normal in April and July, and very greatly in excess in the months of October, November and December, the average flow for November being the highest recorded in that month on the Sudbury for twenty-one years. The result of this distribution of the flow upon sources of water supply was to cause many of the large ponds having comparatively small water-sheds to fail to fill in the spring; but, owing to the early and heavy rainfall in the fall, the drought was not felt so seriously as has been the case in other years. The very low flow of streams in September and the early portion of October was severely felt by those communities supplied from small reservoirs having comparatively large water-sheds, which depend largely upon the daily flow of the streams to prevent a shortage of water.

The chemical analyses of the water supplies and rivers of the State have been continued during the year, 2,250 samples having been examined. The following is a classified list of the waters examined during the year:—

**TABLE I.**

|                                                                                                       |              |
|-------------------------------------------------------------------------------------------------------|--------------|
| From open and covered reservoirs for the storage of ground waters,                                    | 46           |
| From ground-water supplies,                                                                           | 393          |
| Special investigations of regular water supplies affected by tastes, odors, etc.,                     | 19           |
| From ponds and storage reservoirs and their inlets,                                                   | 815          |
| From streams and miscellaneous sources,                                                               | 100          |
| <b>Total from regular water supplies,</b>                                                             | <b>1,373</b> |
| On connection with investigations of new sources of water supply,                                     | 295          |
| With reference to pollution of streams,                                                               | 287          |
| With reference to sewage purification at Worcester, Framingham, Marlborough, Gardner, Medfield, etc., | 246          |
| On connection with the study of epidemics,                                                            | 7            |
| Miscellaneous,                                                                                        | 42           |
|                                                                                                       | <b>877</b>   |
| <b>Total,</b>                                                                                         | <b>2,250</b> |

The examination of the microscopic organisms has also been continued in the waters which have been examined chemically, and those which are found in large numbers in any water at times when there is complaint of its taste or odor have been studied with special attention, with a view to learning the conditions necessary to their existence and development.

With the rapid extension of water-supply systems throughout the State and the constant increase in the use of water has come not only recognition of the necessity that the supply shall be ample in quantity at all times, and free from danger of contamination by animal refuse or other poisonous matter, but also an appreciation of the importance of excellence in other respects; and the possession by a community of a water that is at all times soft, free from taste or odor and of attractive appearance, has a certain commercial value as well, compared with less attractive supplies.

Of the supplies in the State drawn from natural ponds, some have from time to time been affected by the presence of microscopic organisms in such numbers as to cause the waters to become offensive to taste and smell to such a degree in some instances as to lead to the consideration of measures for obtaining a satisfactory supply from another source, at least during times when the water of the present source is unfit for use. The periodic occurrence of such conditions in ponds, which at other times may furnish a water of satisfactory



quality, indicates the necessity of thorough investigation of a source before the construction of works for supplying a community with its water is undertaken.

Investigations as to the quality of water of artificial storage reservoirs, both of those which have been thoroughly prepared for the purpose by the removal of all soil and vegetable matter from the area flowed, and of those where the preparation has been insufficient or where no preparation at all beyond a simple clearing of the area has been made, have shown that, while water often deteriorates greatly in quality when stored in reservoirs of the latter class, on the other hand, the quality of the water is not only unlikely to deteriorate, but is likely to improve by storage in reservoirs thoroughly prepared for the purpose, the degree of improvement depending chiefly on the character of the water as it enters the reservoir and the length of time that it is allowed to remain there.

The occurrence of excessive amounts of iron in ground waters has frequently been referred to in previous reports. Information obtained from systematic examinations of existing sources and from investigations of proposed new supplies has shown that the quality of the water taken from single test wells, from which comparatively little water has previously been drawn, frequently does not furnish a reliable indication as to the probable quality of the ground water of a locality after the comparatively large quantity used by a town or village has been drawn from the ground in the vicinity for a considerable length of time. A satisfactory knowledge on these points can often be obtained only from long-continued pumping from such sources under circumstances which would most readily allow of the development of unfavorable conditions affecting the quality of the water. Such pumping tests, when accompanied with careful observations, are usually valuable in the indications that they may furnish of the probable capacity of a ground-water source.

As a result of its investigations, the Board has frequently called attention to the danger in the use for domestic purposes of water taken directly from running streams exposed to pollution by inhabitants upon their water-sheds; and a marked decrease in the use of such sources has been noted, several communities going to the expense of entirely new sources of supply, to avoid the use of water from polluted streams.

Observations of the operation of the Lawrence city filter have been continued through the year, and a summary of the results of chemical

bacterial analyses of samples of water before and after filtration given in subsequent pages. The following table, which is the result of a careful investigation, shows the total number of deaths from typhoid fever in Lawrence and the deaths from this cause per 100 inhabitants for the year 1895 and the ten previous years:—

TABLE II.

*Deaths from Typhoid Fever in Lawrence, 1885-95.*

| YEAR.     | Total Number of Deaths. | Deaths per 10,000 of Population. | PERSONS KNOWN TO HAVE BEEN EXPOSED TO INFECTION BY— |                                                                |                         |
|-----------|-------------------------|----------------------------------|-----------------------------------------------------|----------------------------------------------------------------|-------------------------|
|           |                         |                                  | Drinking Canal Water.                               | While living out of Town just before falling sick in Lawrence. | Nursing Other Patients. |
| . . . . . | 17                      | 4.2                              | -                                                   | -                                                              | -                       |
| . . . . . | 23                      | 5.75                             | -                                                   | -                                                              | -                       |
| . . . . . | 47                      | 11.75                            | -                                                   | -                                                              | -                       |
| . . . . . | 48                      | 12.                              | -                                                   | -                                                              | -                       |
| . . . . . | 55                      | 13.75                            | -                                                   | -                                                              | -                       |
| . . . . . | 60                      | 13.33                            | -                                                   | -                                                              | -                       |
| . . . . . | 55                      | 12.20                            | -                                                   | -                                                              | -                       |
| . . . . . | 50                      | 11.11                            | -                                                   | -                                                              | -                       |
| . . . . . | 39                      | 8.66                             | -                                                   | -                                                              | -                       |
| . . . . . | 24                      | 5.00                             | 12                                                  | 4                                                              | 1                       |
| . . . . . | 16                      | 3.07                             | 9                                                   | 2                                                              | -                       |

certain facts are to be noted in connection with the figures presented in the table. Investigations by the Board of the causes of the excessive death rates from typhoid fever in Lawrence in the years 1885 and 1890 pointed so strongly to the water supply as one of the important causes that the Board at the beginning of 1891 warned the citizens against its use for drinking except after thorough boiling. Supplies of water pumped directly from the canals are used for various purposes in the mills; this water is in many places easily accessible for drinking and is so used, notwithstanding that city water is also provided. The filter was first operated in September, 1891, and all of the water supplied to the city has been filtered since that time.

In connection with investigations as to the purification of sewage, a large number of samples of sewage and effluent from existing sewage disposal works has been examined. The results of these

investigations are of much value, when taken in connection with the information obtained at the Board's experiment station, in advising cities and towns with reference to the disposal of sewage.

The growth of manufacturing industries and the increase in the population of manufacturing towns and villages have tended to increase the pollution of streams, while the reduced flow of the streams in the past two dry seasons has assisted in making the effect of the pollution more noticeable. The condition of those streams most liable to serious pollution is examined from time to time by means of chemical analyses, and in some cases steps are being taken by local authorities for the removal of causes of pollution.

The subject of the treatment of manufacturing sewage has received much attention during the year, and experiments have been begun with reference to purifying refuse from tanneries, wool-washing and other establishments, drainage from which is a prime factor in the pollution of many streams and watercourses. While the experiments have not yet been carried far enough to warrant any extended statement as to the results obtained, it may be said that sufficient information has been furnished by the investigations thus far made to make it evident that manufacturing sewage may be purified sufficiently to prevent its polluting a stream, at a sufficiently moderate cost to obviate the danger of crippling the manufacturing industries.

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### ADVICE TO CITIES AND TOWNS.

Under the provisions of chapter 375 of the Acts of 1888, entitled "An Act to protect the purity of inland waters, and to require consultation with the State Board of Health regarding the establishment of systems of water supply, drainage and sewerage," the Board is required "from time to time to *consult with and advise the authorities of cities and towns, or with corporations, firms or individuals either already having or intending to introduce systems of water supply, drainage or sewerage, as to the most appropriate source of supply, the best practicable method of assuring the purity thereof or of disposing of their drainage or sewage, having regard to the present and prospective needs and interests of other cities, towns, corporations, firms or individuals which may be affected thereby.* It shall also from time to time consult with and advise persons or corporations engaged or

nding to engage in any manufacturing or other business, drain-  
 or sewage from which may tend to cause the pollution of any  
 nd water, as to the best practicable method of preventing such  
 ution by the interception, disposal or purification of such drain-  
 or sewage: *provided*, that no person shall be compelled to bear  
 expense of such consultation or advice, or of experiments made  
 the purposes of this act. *All such authorities, corporations,*  
*ns and individuals are hereby required to give notice to said Board*  
*their intentions in the premises, and to submit for its advice outlines*  
*their proposed plans or schemes in relation to water supply and*  
*posal of drainage and sewage; and all petitions to the Legislature*  
*authority to introduce a system of water supply, drainage or sew-*  
*ge shall be accompanied by a copy of the recommendation and advice*  
*he said Board thereon."*

during the year 1895 the Board has given its advice to the follow-  
 cities, towns, corporations and individuals who have applied for  
 h advice under the provisions of the general act of 1888, or  
 ler special acts relating to water supply and sewerage.

Replies were made during the year to applications made from the  
 owing sources for advice relative to water supply: Adams (two  
 lies), Amesbury (the Powow Hill Water Company), Billerica,  
 dford, Brookfield, Cohasset, Dighton and Somerset (two replies),  
 Edgartown Water Company, Gloucester, Greenfield, Groton,  
 tfield, Haverhill, Holden, Holyoke, Kingston, Leicester, Leomin-  
 r, Lowell, Montague (Miller's Falls), Montague (Village), Paxton,  
 operell, Pittsfield, Reading, Rutland, Sheffield, Shirley, Stoughton,  
 lpole, Wenham, Westfield, Weston, Williamstown, Winchendon,  
 rentham (Plainville) and Worcester.

Replies relating to sewerage and sewage disposal were made, in  
 wer to applications from the following sources: Amesbury,  
 dover, Brockton, Fairhaven, Framingham, Springfield, Tewks-  
 y, the State Farm at Bridgewater, and Webster.

Replies were also made during the year relative to the subject of  
 lution of streams, to certain authorities and other parties in the  
 owing towns: to the board of health of Danvers, relative to the  
 lution of Crane's River; to the selectmen of Millbury, in reply  
 a communication relative to the pollution of the Blackstone  
 er by the city of Worcester; to the selectmen of Shrewsbury,  
 tive to the pollution of Lake Quinsigamond by the sewage  
 the State Lunatic Hospital at Worcester; and to the selectmen

of Northborough, in reply to a letter relative to the pollution of Lake Chauncy by the sewage of the State Lunatic Hospital at Westborough.

### WATER SUPPLY.

The following is the substance of the action of the Board during the past year, in reply to applications for advice relating to water supply : —

**ADAMS.** The committee on water supply of the Adams Fire District applied to the Board Feb. 21, 1895, for its advice relative to taking a ground-water supply from the valley of the Hoosac River, and as to the best method of supplementing its water supply. The Board replied to this application as follows : —

BOSTON, May 2, 1895.

The portion of the valley indicated by you as a possible ground-water source is in the vicinity of the Hoosac River, south of Cheshire Harbor. This locality has been examined by one of the engineers of the Board, but, as no tests have been made by driving wells or otherwise to show the character of the material beneath the surface and to obtain a sample of water for analysis, it is impracticable to advise definitely at the present time as to the probable quality and quantity of water to be obtained at this place.

A sample of water collected April 17, 1895, from a flowing tubular well in the valley of the river at Zylonite, was analyzed, and found to be so hard that it would not be of satisfactory quality for many of the purposes for which a public water supply is used ; and the same statement may be made with regard to the water supplied from the wells of the North Adams water works.

In view of these results, there is much doubt as to whether a water supply contained from the ground as proposed would be of satisfactory quality ; and this point can be definitely settled only by determining the hardness and other characteristics of a sample of water taken from the ground at the proposed location.

While, as already stated, it is impracticable to advise definitely at this time as to the probable quantity of water, it may be said that the surface indications point to a limited rather than to an ample supply.

In view of the insufficiency of the present sources of supply during the dry portion of the past year, and the uncertainty as to the best method of obtaining a supplementary supply, the Board advises you to have the whole question of the water supply of the town more thoroughly investigated, with the aid of an engineer skilled in such work.

In addition to the investigation with regard to obtaining a supplementary ground-water supply, it is desirable to ascertain the quality and quantity of

er flowing during the dry portion of the year in streams not now used, which may be available for supplying your town; and to ascertain whether it is not feasible to build a reservoir to store enough water to maintain the supply during the portions of the year when the natural flow of the streams is insufficient. It would also be well to have the quantity of water used by the town measured, with a view to determining whether the consumption of water is excessive; and, if this should be found to be the case, it might be feasible to materially reduce the consumption by preventing leakage and waste, and in this way make the consumption of water correspond more nearly with the capacity of the sources.

This Board will aid you in making such investigations by analyzing samples of water, and by furnishing to your engineer any information now in its possession bearing upon the question; and will, upon application, when you have further information to present, advise you further as to the most appropriate method of increasing your supply.

On Aug. 1, 1895, the water committee again applied to the Board for its advice, relative to taking an additional supply of water from the land in the Hoosac valley above Cheshire harbor and below the village of Cheshire. The Board replied to this application as follows:—

BOSTON, Oct. 3, 1895.

The State Board of Health received from you on Aug. 1, 1895, an application asking for the advice and approval of the Board of a plan for obtaining an additional water supply for the Adams fire district from the ground in the valley of the Hoosac River above Cheshire harbor and below the village of Cheshire by means of tubular wells, the water to be pumped into the main pipe leading from Bassett Brook reservoir, one of the present sources of supply to the town.

Accompanying the application is a report by your engineer, containing the results of investigations made by him of various sources in the vicinity of the town, and the Board has also caused a further examination of these sources to be made by one of its engineers. As a result of these investigations, it is found that the flow of the brooks at present used for the supply of the town and of two other brooks in the vicinity on September 6 and when there had been no rain for several days, was about as follows:—

|                          |                          |
|--------------------------|--------------------------|
| Bassett Brook, . . . . . | 275,000 gallons per day. |
| Dry Brook, . . . . .     | 90,000 gallons per day.  |
| Tophet Brook, . . . . .  | 127,000 gallons per day. |
| South Brook, . . . . .   | 315,000 gallons per day. |

Samples of water collected September 7 from your present sources of supply and from other sources examined have been analyzed, and a com-

parison between the results of these analyses and of the analyses of samples collected from these same sources in the earlier portion of the year may be made from the following table:—

| SOURCE.                                    | Hardness<br>September 7. | Hardness in<br>Earlier Portion of<br>the Year. |
|--------------------------------------------|--------------------------|------------------------------------------------|
| Tophet Brook, . . . . .                    | 7.6                      | 1.4                                            |
| Dry Brook, . . . . .                       | 9.4                      | 1.6                                            |
| Bassett Brook, . . . . .                   | 3.2                      | 1.1                                            |
| South Brook, . . . . .                     | 3.2                      | 1.6                                            |
| Test well above Cheshire Harbor, . . . . . | 11.0                     | <div> 10.3*<br/> 10.6*<br/> 14.8* </div>       |
| Renfrew well, . . . . .                    | 12.6                     | 12.3                                           |

\* Three test wells.

The results of the analyses show that the hardness of the water of Tophet and Dry brooks was several times as great in September as in the earlier portion of the year, while the increase in the hardness of the water of South Brook was comparatively small. From the results of the examinations it appears that a supply of water somewhat greater than the amount yielded by Bassett Brook and of equally good quality with respect to hardness, would be furnished by South Brook. The quality of this water is also satisfactory in other respects.

It appears from the report of your engineer that a storage reservoir having a capacity of about 43,000,000 gallons can be constructed upon this brook and that the water of this reservoir could be supplied to the town by gravity by laying a pipe to connect with the pipe leading from your present Bassett Brook reservoir. The estimates of cost indicate that the first cost of a supply from this source would be about two and one-half times as great as that from tubular wells in the valley of the Hoosac River above Cheshire Harbor; but the annual cost of maintenance, including interest, would not be proportionally greater, because the water of South Brook would be delivered to the town by gravity, and the cost of pumping would be avoided.

By taking a supply from South Brook the town would obtain a soft water of excellent quality for the purposes of a public water supply. The water of the test wells, on the other hand, though of excellent appearance and practically free from organic matter, is so hard, owing to the presence of lime in solution, that it would be undesirable for drinking and objectionable for many other purposes of a domestic water supply.

The Board regards it of importance to the health of the town to avoid very hard waters, and obtain as soft water as practicable. The water of South Brook is the most satisfactory in this respect, and the Board is of opinion that by the construction of a reservoir in the upper part of Dry Brook a softer water may be obtained in a dry time than is now obtained from this brook.

By the provisions of the act passed last spring, no authority is given to the town of Adams to take any source in Cheshire south of the southerly boundary of the former town of New Providence, which excludes South Brook. In view, however, of the excellent quality of water obtainable from this source, the Board would advise that you take measures to secure the right to take the water of this brook, subject to the right of the town of Cheshire to such an amount of water from this source as may be needed for the supply of the town in addition to the waters of Thunder and Kitchen Brooks when they shall have been fully developed.

The population of Cheshire has steadily decreased for the past fifteen years, and, moreover, the sources in the region from which its present supply is taken have not been fully developed, so that there is no present indication that any water need be drawn from South Brook for the supply of Cheshire.

The yield of South Brook, with a storage reservoir having a storage capacity of 43,000,000 gallons, would, in connection with your present sources, amount to about 1,100,000 gallons per day in the drier months of a very dry season.

Measurements made by your engineer in the early part of July indicate that at that time the consumption of water in the town amounted to 1,150,000 gallons per day, equivalent to 147 gallons per person per day. This is an excessive consumption and is greater than that of any other city or town in the State where records of the consumption of water are kept. There appears to be no good reason why the consumption should be larger than that of other towns where the conditions are similar, and by reducing to a reasonable amount the capacity of your present works, with the addition of a storage reservoir on South Brook, will be sufficient for the town till a large increase over the present population takes place.

**AMESBURY.** The Powow Hill Water Company applied to the State Board of Health March 18, 1895, for its advice relative to obtaining an additional supply of water from the ground near Main Street in that town. The Board replied as follows:—

Boston, June 6, 1895.

The Board has caused examinations of the present and proposed sources of supply and analyses of water from each of the sources to be made. From



parison between the results of these analyses and of the analyses of samples collected from these same sources in the earlier portion of the year may be made from the following table : —

| SOURCE.                                    | Hardness<br>September 7. | Hardness in<br>Earlier Portion of<br>the Year. |
|--------------------------------------------|--------------------------|------------------------------------------------|
| Tophet Brook, . . . . .                    | 7.6                      | 1.4                                            |
| Dry Brook, . . . . .                       | 9.4                      | 1.6                                            |
| Bassett Brook, . . . . .                   | 3.2                      | 1.1                                            |
| South Brook, . . . . .                     | 3.2                      | 1.6                                            |
| Test well above Cheshire Harbor, . . . . . | 11.0                     | <div> 10.3*<br/> 10.6*<br/> 14.8* </div>       |
| Renfrew well, . . . . .                    | 12.6                     | 12.3                                           |

\* Three test wells.

The results of the analyses show that the hardness of the water of Tophet and Dry brooks was several times as great in September as in the earlier portion of the year, while the increase in the hardness of the water of South Brook was comparatively small. From the results of the examinations it appears that a supply of water somewhat greater than the amount yielded by Bassett Brook and of equally good quality with respect to hardness, would be furnished by South Brook. The quality of this water is also satisfactory in other respects.

It appears from the report of your engineer that a storage reservoir having a capacity of about 43,000,000 gallons can be constructed upon this brook and that the water of this reservoir could be supplied to the town by gravity by laying a pipe to connect with the pipe leading from your present Bassett Brook reservoir. The estimates of cost indicate that the first cost of a supply from this source would be about two and one-half times as great as that from tubular wells in the valley of the Hoosac River above Cheshire Harbor ; but the annual cost of maintenance, including interest, would not be proportionally greater, because the water of South Brook would be delivered to the town by gravity, and the cost of pumping would be avoided.

By taking a supply from South Brook the town would obtain a soft water of excellent quality for the purposes of a public water supply. The water of the test wells, on the other hand, though of excellent appearance and practically free from organic matter, is so hard, owing to the presence of lime in solution, that it would be undesirable for drinking and objectionable for many other purposes of a domestic water supply.

The Board regards it of importance to the health of the town to avoid very hard waters, and obtain as soft water as practicable. The water South Brook is the most satisfactory in this respect, and the Board is of opinion that by the construction of a reservoir in the upper part of Dry Brook a softer water may be obtained in a dry time than is now obtained from this brook.

By the provisions of the act passed last spring, no authority is given to the town of Adams to take any source in Cheshire south of the southerly boundary of the former town of New Providence, which excludes South Brook. In view, however, of the excellent quality of water obtainable from this source, the Board would advise that you take measures to secure the right to take the water of this brook, subject to the right of the town of Cheshire to such an amount of water from this source as may be needed for the supply of the town in addition to the waters of Thunder and Kitchen Brooks when they shall have been fully developed.

The population of Cheshire has steadily decreased for the past fifteen years, and, moreover, the sources in the region from which its present supply is taken have not been fully developed, so that there is no present indication that any water need be drawn from South Brook for the supply of Cheshire.

The yield of South Brook, with a storage reservoir having a storage capacity of 43,000,000 gallons, would, in connection with your present works, amount to about 1,100,000 gallons per day in the drier months of a very dry season.

Measurements made by your engineer in the early part of July indicate that at that time the consumption of water in the town amounted to 1,150,000 gallons per day, equivalent to 147 gallons per person per day. This is an excessive consumption and is greater than that of any other city or town in the State where records of the consumption of water are kept. There appears to be no good reason why the consumption should be larger in that of other towns where the conditions are similar, and by reducing to a reasonable amount the capacity of your present works, with the addition of a storage reservoir on South Brook, will be sufficient for the town until a large increase over the present population takes place.

**AMESBURY.** The Powow Hill Water Company applied to the State Board of Health March 18, 1895, for its advice relative to obtaining an additional supply of water from the ground near Main Street in that town. The Board replied as follows:—

Boston, June 6, 1895.

The Board has caused examinations of the present and proposed sources of supply and analyses of water from each of the sources to be made. From

the information thus obtained the Board finds that the present sources are likely to be inadequate in a dry year for supplying the present consumers with water.

The analyses of samples of water taken from the test well at the proposed source show that the water is at present of excellent quality, and, although it may change somewhat in character with a continuous draught upon this source, it will probably remain of suitable quality for water-supply purposes, unless there should be a considerable increase in the population in the vicinity of the well.

The conditions, however, do not appear favorable for obtaining any large additional supply of water from this source, and, as it is the general experience of cities and towns that the amount of water consumed increases much faster than the population, both on account of the increasing proportion of the inhabitants supplied with water and the increasing use of water per consumer, it is not probable that the proposed additional supply would meet the requirements for more than a very few years.

The Board, therefore, believes it to be desirable, in order to provide adequately for the present and future needs of the town, and probably in the interest of true economy, to obtain a larger additional supply of pure water than can be obtained from the proposed source near Main Street, and advises that you make further investigations, with the aid of a competent engineer, to ascertain whether it is not feasible to obtain such a supply.

**BILLERICA.** J. Nelson Parker and other petitioners applied to the Board March 6, 1895, for its advice relative to the use of the water of Nutting's Pond in Billerica for fire and domestic purposes for that town. The Board replied to this application as follows:—

Boston, April 4, 1895.

The State Board of Health has considered your application relative to a proposed water supply to be taken from Nutting's Pond in Billerica, has had the pond examined by one of its engineers, and has caused a chemical and microscopical examination of a sample of water collected from it to be made.

The chemical examination shows that the water has a high color and contains a large amount of organic matter, much of which is in suspension; and the microscopical examination shows that a large part of the suspended organic matter is a minute organism, of a kind which is known to have caused bad tastes and odors in other water supplies of the State. The water, therefore, although not polluted by sewage, and no worse in other respects than that furnished to a few places in the State, cannot in its present condition be regarded as of satisfactory quality for the purposes of a public water supply.

The Board therefore advises the investigation of other available sources, to ascertain if a better one cannot be found; and it may also be well to determine whether the pond can be improved as a source of water supply by any changes which it is feasible to make in or near it, and to have samples of water collected from the pond at other seasons of the year and analyzed.

**BRADFORD.** An application was received from the Bradford Water Company for the advice of the Board, relative to the introduction of new water supply from Johnson's Pond in Boxford and Groveland, and as to the improvement of the existing supply by methods outlined by the engineer of the company. The Board replied to this application as follows:—

Boston, March 15, 1895.

Samples of water from your present source have been examined by this board from time to time since 1889; and, while the water at first was of very good quality, it has been deteriorating in recent years, and there is no reason to expect that it will become better, but rather that it will continue to deteriorate.

The quality of the water might be improved by proper treatment, but there is uncertainty as to whether it could be made a wholly satisfactory water, and the cost of thorough treatment might be large in comparison with the cost of obtaining a satisfactory water in other ways; moreover, the capacity of the source is but little in excess of the amount of water now impounded. The Board, therefore, believes that the present source should be abandoned as soon as a better one can be made available.

The Board has caused examinations to be made by its engineers of all the sources from which it seemed at all probable that a satisfactory supply for the town of Bradford might be obtained; and from this examination concludes that there is no opportunity to obtain a satisfactory groundwater supply, and that Johnson's Pond is the most appropriate source from which to take a supply of surface water.

An analysis of water from this pond, taken in connection with an examination of the pond and its drainage area, shows that the water is of good quality, and suitable for all the purposes of a public water supply; and the pond will furnish a sufficient quantity of water to supply the towns of Bradford, Groveland and Boxford, and still leave as much water as is necessary to meet the requirements of the mills situated upon the stream which flows from the pond, for all purposes except water power.

The plan for improving the quality of the water from the present source, involving the construction of new works, as outlined in the report of your engineer, contemplates passing all of the water used through the existing distributing reservoirs, so that a portion of the iron contained in the water may become oxidized, and settle to the bottom of the reservoirs.

The plan proposed by him should cause a considerable improvement in the quality of the water, which might be increased somewhat if the water were pumped to a greater height than the water in the reservoir, and made to come in contact with the air as much as possible in falling. A still greater improvement would result if, in addition to letting the water drop through the air, it were given further opportunity for aeration by passing it through a filter composed of fragments of coke large enough to permit water and air to pass very freely. This filter should be situated above the level of the water in the reservoirs, and should have a surface area of about 400 square feet.

**BROOKFIELD.** The water commissioners of Brookfield applied to the Board Feb. 6, 1895, for its advice relative to taking a public water supply from South Pond in that town. Advice was also asked as to the "use of this source in common by the towns of West Brookfield and Warren," in addition to Brookfield, through the medium of the same works. The Board replied to this application as follows : —

Boston, July 11, 1895.

The Board finds that the quality of the water at the northerly end of the pond is at times unfavorably affected by the back flow of water from Quaboag Pond, the water of which is, in its natural state, inferior to that of South Pond, and is also polluted by the sewage discharged into its feeders from the town of Spencer; but analyses of samples of water collected at a distance from the outlet of the pond show that if the back flow from Quaboag Pond is prevented, South Pond will furnish a water of excellent quality for all the purposes of a public water supply.

The quantity of water which the pond will furnish is undoubtedly much in excess of the quantity which will be required for the supply of the town.

In addition to the examinations of South Pond, the Board has caused a general examination to be made of other sources from which it seemed possible that a supply might be obtained, and has also caused analyses to be made of samples of water collected from these sources. These examinations were not carried far enough to be wholly conclusive, but they did not indicate that there was any more appropriate source than South Pond from which to obtain a supply for the town.

You also stated in your application that "advice is desired as to the suitability and sufficiency of this source for the towns of West Brookfield and Warren if supplied in common with Brookfield through the medium of the works as proposed by the latter town." It has already been indicated that if provision is made for preventing the back flow from Quaboag Pond the water of South Pond will be of suitable quality for water-supply purposes; and the quantity of water which this source will furnish is sufficiently large to supply all three towns for a long time in the future.

In the absence of any request for advice from the towns of West Brookfield and Warren, the Board has made no investigations for the purpose of ascertaining whether the three towns named can best obtain a supply of water by taking it from this source through the medium of a single system of works.

**COHASSET.** The Cohasset Water Company applied to the Board Nov. 22, 1894, for its advice relative to increasing their water supply by means of driven wells, or one large well, about 1,000 feet south of the present system of driven wells. The Board replied to his application as follows:—

Boston, July 11, 1895.

The Board has caused analyses to be made of samples of water sent in by you from one of the test wells at this place, and finds that the water is one which has at some time been polluted and subsequently very thoroughly purified by its passage through the ground. It seems probable that if water were pumped continually from a well or wells at this place, a part of the water would come from the populated territory north-east of the railroad, and that, in addition to showing to a still greater degree the effect of previous pollution, it might also be less perfectly purified by its passage through the ground. For these reasons the Board does not regard this source as a desirable one from which to take an additional water supply.

In view of the undesirable character of the water of the proposed source, the Board has caused a general examination to be made of other surface and ground-water sources in the vicinity of the town. It finds that the water of the surface sources has generally a high color and contains in most cases a large amount of organic matter, mainly of vegetable origin; and, while it is possible that at least one of these might be made to furnish sufficient quantity of water, the quality of the water would not be nearly so satisfactory as that of a good ground water.

The examinations indicate that the most favorable locality in which to make investigations for a ground-water supply is in the vicinity of Bound Brook, above the village of North Scituate. The conditions here are not on the whole very favorable for obtaining a supply of this kind, but so far as could be judged from surface indications there is no more favorable locality within a reasonable distance of the town, and in view of the comparatively small amount of water needed, it seems possible that a satisfactory supply of ground water may be obtained at this place.

The Board will, upon application, advise you further in this matter when additional investigations have been made, and will furnish you with such information as may be in its possession concerning the various sources of water supply in the vicinity of the town.

DIGHTON and SOMERSET. An application was received Jan. 17, 1895, from James H. Flint and others (petitioners for incorporation as the Dighton and Somerset Water Company), for the advice of the Board relative to the taking of the waters of Muddy Brook and Segreganset River and their tributaries in the town of Dighton, and the water from any artesian or other wells which may be dug, bored or driven for the purpose in these towns, as sources of domestic water supply for Dighton and Somerset. The Board replied to this application as follows : —

Boston, March 25, 1895.

The Board has caused examinations of the proposed sources of supply to be made, as far as has been found practicable at this season of the year. Samples of water from Muddy Brook, Sunken Brook and the Segreganset River have been analyzed, and each has the brownish color and other characteristics which water acquires from contact with vegetable matter in swamps or shallow ponds, and on this account the water taken directly from either of these streams would not be of entirely satisfactory quality.

The water-sheds of both Muddy Brook and Sunken Brook are so small that they will not furnish enough water to supply the towns in a dry summer, unless a considerable amount of the water flowing in the wetter portions of the year is stored in reservoirs. There does not appear to be an opportunity for building reservoirs upon these streams of sufficient depth to prevent the water from deteriorating unless the reservoirs are deepened by excavating; and in order to obtain a sufficient amount of storage in this way the reservoirs would be very costly.

The Segreganset River has a much larger water-shed than the brooks above referred to, and can readily be made to furnish all of the water required for both towns.

A general examination was made of other sources, and there seemed to be more favorable opportunities for obtaining a water supply in Dighton than in Somerset; and, should it be found upon further investigation that, as now seems probable, the supply for both towns should come from sources in the town of Dighton, the two towns could be supplied more economically from one system of works than from independent systems.

Owing to the somewhat swampy character of the water flowing in most of the streams in this vicinity, it is desirable that a supply of good ground water should be obtained if possible; and the Board advises that investigations be made to determine whether it is feasible to obtain a supply of this kind, but cannot with its present information advise definitely as to the best place for making the investigations.

The Board will, if you so request, give you further advice later in the year, if you have more definite information to present as to the feasibility

obtaining a ground-water supply, or should find a more satisfactory surface-water source.

On April 26 the Board received a further application from the petitioners for further advice relative to the use of the water of the Swamp Brook and of the Segreganset River, or of so much of either source as may be necessary to supplement a ground-water supply. The Board replied to this second application as follows:—

BOSTON, May 25, 1895.

The State Board of Health received from you April 26, 1895, an application for further advice relative to using, for the water supply of the towns of Dighton and Somerset, the water of Pine Swamp Brook and of Segreganset River, or so much of the water of either source as may be necessary to supplement the supply obtained from the ground. You also state that additional information has been obtained as to the character of ground in the vicinity of these streams.

The Board in its last reply made the following statement: "Owing to the somewhat swampy character of the water flowing in most of the streams in this vicinity, it is desirable that a supply of good ground water should be obtained if possible, and the Board advises that investigations be made to determine whether it is feasible to obtain a supply of this kind," and concluded its reply as follows: "The Board will, if you so request, give further advice later in the year, if you have more definite information presented as to the feasibility of obtaining a ground-water supply, or should find a more satisfactory surface-water source."

Further examinations and analyses made by the Board indicate that the waters of Pine Swamp Brook and the Segreganset River, owing to their brownish color and accompanying taste and odor, would not be of satisfactory quality for water-supply purposes unless taken indirectly by filtration through the ground.

The additional information submitted by you as to the character of the ground in the vicinity of these streams was obtained by driving three test wells near the junction of Pine Swamp Brook and the Segreganset River. These tests show that there is more or less porous material beneath the surface from which water can be pumped, and, although the conditions do not appear to be favorable for obtaining any very abundant supply of ground water, yet it may be feasible to obtain the comparatively small quantity needed for these towns by means of a well supplemented by collecting cisterns or galleries extended for a sufficient distance up the valleys of the Swamp Brook and the Segreganset River.

Two samples of water were procured from the wells during the tests; but,



judging from the analyses of samples of water collected from a spring and from two wells not very far away, it is probable that the water to be obtained from the ground would be of good quality.

The examinations have been sufficiently extended to indicate that the ground in the vicinity of the Pine Swamp Brook and the Segreganset River is likely to be the best source within the limits of these towns from which to take a water supply; but the information at present available is too limited to enable the Board to give a definite opinion upon this point.

**EDGARTOWN.** An application was received from Joseph K. Nye, March 12, 1895, petitioner for incorporation as the Edgartown Water Company, for the advice of the Board relative to taking the water of certain springs in a valley south-west of the village of Edgartown as a source of public water supply. The Board replied to this application as follows:—

Boston, March 26, 1895.

The State Board of Health received from you on March 12, 1895, an application relative to a proposed water supply for Edgartown, Mass., which contains the following statement: "The proposed source of supply is from a tract of land situated about four thousand feet in a south-westerly direction from the village of Edgartown. The land is situated in a valley running in a south-easterly direction, the point of location being at the head of this valley, something over a mile from Edgartown Harbor. At this point are a number of springs, and it is proposed to drive a sufficient number of pipe wells to yield the required amount of water."

The Board has caused an examination of the locality referred to to be made by one of its engineers; but, as the ground has not been tested by driving wells or otherwise, it is impracticable at the present time to give any definite opinion as to the quantity and quality of water to be obtained from the proposed source. Judging from surface indications, however, it is not improbable that a sufficient quantity of water may be obtained from the ground in this vicinity; and, judging from experience with the water supplies of Cottage City and Vineyard Haven, which are derived from ground apparently similar in character, it is probable that the water will be of good quality.

The Board will advise you further upon this subject when you have made tests of the ground and have additional information to present.

**GLOUCESTER.** The Board received the following application July 3, 1894, from the mayor of Gloucester, for the advice of the Board relative to the water supply of that city:—

GLOUCESTER, Mass., June 30, 1894.

*To the State Board of Health.*

The city of Gloucester, by its duly appointed committee, desires and respectfully requests that further and more complete investigations of its present and prospective sources of water supply be made during this year, in order that safe and final conclusions may be reached by the city concerning the present and ultimate capacities of the sources from which water is now being actually supplied to the city, and those which may be added in reinforcement when an increase becomes necessary, among the latter to be included Chebacco Pond, with its tributaries and water-sheds. The city desires that the question of quality, in each case, be exhaustively considered; that present and future improvements which may be necessary to raise the quality to the highest degree attainable with reasonable economy be indicated; and that, so far as possible, some idea of the relative costs of making these improvements in each case be given.

Directions have been given to the city engineer "to obtain all records of varying depths of water in the present sources and kindred data which may have any bearing upon the case," and the city engineer will follow any suggestions which the Board may give in this line, and will promptly make such returns as the Board may indicate.

The city desires and respectfully requests that analyses of the waters of the sources involved be made with regularity during the remainder of this year, the samples to be taken simultaneously, if practicable.

For the joint special committee on water supply of the city of Gloucester,

(Signed)

BENJ. F. COOK,

*Mayor, and Chairman of Committee.*

To this application the Board replied as follows:—

BOSTON, April 12, 1895.

In accordance with your request, an engineer of the Board visited your present and prospective sources twice in the month of July, 1894, and made arrangements for having samples of water taken from the present sources by your city engineer, acting in conjunction with a representative of the Gloucester Water Company, and from prospective sources by your city engineer. These samples were collected about once a month until February, 1895, making the total number of samples collected and analyzed 64.

From time to time your city engineer and Mr. Percy M. Blake, the engineer especially engaged upon the water-supply investigation, have furnished information and plans, giving the results of surveys and observations bearing upon the question of the capacity of present and proposed sources;

and, finally, we have received the supplementary report of Mr. Blake upon a municipal water supply for the city of Gloucester, dated March 9, 1895.

With the information thus furnished and that obtained by several examinations made by an engineer of this Board, the questions submitted by you have been carefully considered.

The conclusions reached by the Board as a result of this consideration are substantially the same as those contained in the reply to you upon the same subject, dated April 27, 1894, which were as follows:—

“The Board finds that the present sources have sufficient capacity in a dry year to supply the quantity of water now used by the city; but the population now supplied is much less than the total population, and the amount of water consumed is increasing from year to year, so that it will be necessary before long either to develop the sources now used or to obtain a further supply from other sources. If the present sources and those in their vicinity should be fully developed they would furnish fully double the quantity of water now used, and make a further supply unnecessary at the present time.

“The water supplied from the present reservoirs of the Gloucester Water Company is practically free from pollution by sewage, and in other respects it is a fairly satisfactory water for the purposes of a public water supply, and is somewhat better at the present time than the water in Chebacco Lake. It could undoubtedly be improved, however, by the removal of stumps, soil and vegetable matter from the bottom and sides of the reservoirs. The water from other sources near the present ones in West Gloucester has not been analyzed, but from an examination of these sources it seems probable that they will furnish as good water as the sources now supplying the city.

“Chebacco Lake will furnish a somewhat larger quantity of water than could be obtained from all of the available sources in West Gloucester if they were fully developed, and is probably the most available source of water supply for Gloucester, independent of the present works. As already indicated, the water is not quite as good as that now supplied to the city, and it is doubtful if it would prove a satisfactory water for water-supply purposes unless improved in some way, which cannot be determined with the information now available.

“The Chebacco ponds are located in the towns of Essex, Hamilton and Wenham, and are only a short distance from Manchester, and may prove the most available source of water supply or additional water supply for these towns; moreover, it is not improbable that they may prove the most available source from which to take an additional water supply for Salem and Beverly, when the capacity of the sources from which these places are now authorized to take water has been reached. Under these circumstances, the Board is of the opinion that the Chebacco ponds are not at

present the most appropriate source of supply for the city of Gloucester; and if rights in these ponds are granted to Gloucester, they should be limited by proper reservations for other places."

Now that further information is available and further examinations have been made, the Board is enabled to give more specific advice in some respects and to answer more fully the questions asked by you.

The Board now believes that the present sources and others in their vicinity can, at a reasonable cost, be improved and developed to such an extent that they will furnish about three times the quantity of water now used, and the quality of the water to be obtained from the added sources will be as good or better than that now supplied to the city from the present sources.

The nature of the work to be done to improve the quality of the water of the sources now used is, as indicated in the former reply, the removal of stumps, soil and vegetable matter from the bottom and sides of the reservoirs. In adding new sources the same policy should be pursued with regard to any reservoirs which may be built, and suitable channels should also be provided for collecting and conveying the water to the reservoirs in such a manner that it will not be injuriously affected by coming in contact with leaves, peat and other vegetable matter in swamps.

Chebacco Pond will furnish a somewhat larger quantity of water than all of the available sources in West Gloucester, when developed as above indicated; but the quality of its water is not quite as good as that supplied from the sources now used, and would compare still more unfavorably with the quality of the water to be obtained from the West Gloucester sources when improved and developed. The investigations thus far made have not shown that the quality of the lake water can be improved at what would be, at the present time, a reasonable cost.

The cost of taking water from Chebacco Lake would be considerably larger than that of properly developing all of the available sources in West Gloucester, with the further disadvantage in the former case that practically the whole expenditure has to be made at one time, while in the latter the expenditures for different additions and developments can be made from time to time, as an increased amount of water is needed.

If the city of Gloucester, by reason of its growth and the increased use of water, should reach the capacity of the sources in West Gloucester, Chebacco Lake will probably be at such time the most appropriate source from which to take an additional water supply.

**GREENFIELD.** An application was received from the selectmen of Greenfield, Nov. 30, 1894, for the advice of the Board relative to taking an additional supply of water for the town from the Green

River at a point near the "Poor Farm." The Board replied to this application as follows : —

Boston, March 15, 1895.

You state that it is the purpose to take water at a point on the west boundary of land owned by the town of Greenfield and known as the "Poor Farm;" and the Board has since been informed that the water is to be taken from a crib or well sunk in the gravel beside the river, rather than directly from the river itself. It is further understood that this supply is to be obtained by pumping, and is to supplement the present gravity supply from Glen Brook during the drier portion of the year.

The water of the Green River is somewhat harder than that obtained from the present source, but is not hard enough to be objectionable. In other respects the analyses indicate, as far as analyses can, that the water is of excellent quality for all the purposes of a public water supply. There is a risk, however, in taking water directly from a stream which has any population near it. But, in the present case, the risk is comparatively slight on account of the extremely small population. Still it would be advisable to take the water from a well sunk near the river, as proposed, in preference to taking it directly from the river.

Before sinking a well of this kind, examinations should be made to determine that the material adjacent to the river is porous to a considerable depth below the level of the water in the river; and, if such material should not be found at the point indicated in your application, the Board advises that you should make similar examinations of the ground beside the river near the point where Allen Brook enters it, as the examinations made by one of the engineers of the Board indicate that favorable ground in which to sink a well may be found at this place.

GROTON. The committee on water supply of Groton applied to the Board Jan. 12, 1895, for its advice relative to Baddacook Pond and springs near Cady Pond as sources of water supply for Groton. The Board replied to this application as follows : —

Boston, Nov. 4, 1895.

The Board has caused an examination of these sources to be made by one of its engineers, and samples of the water to be analyzed.

The quality of the water of springs near Cady Pond is excellent in most respects, but its hardness, which appears to be due to the presence of limestone in the ground through which the water percolates, is such as to make it very unsatisfactory for many of the purposes of a public water supply. There is much doubt also as to whether the quantity of water which the springs would furnish in a very dry season would be sufficient for the supply of the town after water shall have come into general use.

Baddacook Pond would furnish an abundant supply of water for the town, and chemical analyses show that its hardness would be only about one-third of that of the springs near Cady Pond. The water is somewhat colored, however, and contains a considerable amount of organic matter. Microscopical examinations, moreover, indicate that it may contain at times in summer a considerable number of minute organisms, which impart water an unpleasant taste or odor.

With regard to the comparative merits of the two sources, it may be said that Baddacook Pond would be preferable as a source of public water supply, all things considered, to the springs near Cady Pond, but there is no doubt that if a source capable of furnishing a sufficient supply of ground water of good quality could be obtained, it would be more satisfactory than the water of Baddacook Pond. With a view to learning whether it was feasible for the town to obtain a ground-water supply within a reasonable distance, the Board has caused an examination to be made in a general way of the territory in the vicinity of the town. As a result of this investigation, the Board finds that the surface indications appear to be favorable to obtaining a considerable quantity of water from the ground at several places, the most favorable being in the vicinity of Baddacook Pond, particularly along the south-westerly side of the pond and in the valley of a small tributary which enters the pond on its westerly side. Chemical examinations of the water of springs in the latter locality indicate that the hardness of the water is about the same as that of the water of Baddacook Pond.

The Board would, therefore, advise that, before deciding definitely upon a source of supply, further investigations be made, with a view to determining whether it is feasible to obtain from the ground at either of these places a water of satisfactory quality and in sufficient quantity for the supply of the town. The Board will, upon application, advise you further in this matter when you have additional information to present.

**HATFIELD.** The selectmen of Hatfield applied to the Board Jan. 1, 1895, for its advice relative to taking the water of a brook in the westerly part of the town as a source of public water supply for Hatfield. The Board replied as follows:—

Boston, March 1, 1895.

At the time when an engineer of the Board visited Hatfield to examine the proposed source, there was so much snow upon the ground that it was not feasible to reach the site which your engineers regarded as most satisfactory for the proposed dam, but he succeeded in obtaining a sample of water from the brook between the upper and lower sites for the dam.

The analysis of this sample, taken in connection with the character of the water-shed, indicates that the water is of excellent quality for the purposes of a public water supply.

It was not feasible under the circumstances to judge from an examination of the locality whether the brook at the upper site will furnish a sufficient quantity of water for the town; but the report of your engineers of the measured flow in September, 1894, indicates that it will do so.

The Board regards the source as an appropriate one from which to take a water supply for the town of Hatfield.

**HAVERHILL.** The water board of Haverhill applied to the State Board of Health Jan. 15, 1895, for its advice relative to introducing an additional supply of water for Haverhill from East Meadow River in that city by constructing a dam and making a storage basin, the water to be pumped from this basin to Lake Kenoza, the source of the present high-service supply of the city. The Board replied to this application as follows:—

Boston, June 6, 1895.

Regarding this source of supply and the method of utilizing the water from it you make the following statement:—

“This additional supply for the city of Haverhill is proposed to be taken from the East Meadow River, in the easterly portion of the city, at Millvale, where it is proposed to construct a dam and create a storage basin. The area of the basin will be approximately 47 acres; the depth of water at the dam will be about 14 feet in the deepest place. The estimated capacity of this basin is 118,000,000 gallons. It is proposed to remove all mud and vegetable matter from the site of the basin. The area of the water-shed above the dam is approximately 7.75 square miles.

“A pumping station will be erected, with a pumping plant of sufficient capacity to pump all of the water needed in any year, during the five or six months of greatest flow. The water to be pumped through about one mile of twenty-four-inch pipe to Kenoza Lake, the source of the present high service supply of Haverhill.

“This lake has an area of 225 acres at elevation 110. The estimated storage capacity is 600,000,000 gallons in the upper ten feet in depth, or to the top of the intake of the new pumping station proposed to be built at Kenoza Lake in connection with this improvement.

“The difference in level of the Millvale basin and Kenoza Lake is 64 feet, the proposed high-water level of the former being at elevation 46.

“The plan of operation will be to pump the flow of East Meadow River into Kenoza Lake and store it there, using the storage in the Millvale basin if necessary.

basin will equalize the flow of the stream and allow of a pump of no greater capacity than the average daily flow for the as much of it as is required by the consumption."

application was accompanied by the report and plans of your Mr. Freeman C. Coffin, relative to providing an additional water for your city.

tate Board of Health has, from time to time, for many years, samples of water from the present sources of supply, viz., Kenozaystal Lake, Round Pond and Plug Pond, and regards the water these sources except Plug Pond as of suitable quality at the time for drinking.

amount of water consumed by the city is not definitely known, only the portion pumped from Kenoza Lake is measured, but, from the estimates made by your engineer and similar estimates of an engineer of this Board, the average consumption of water in three years from 1892 to 1894, inclusive, was 2,800,000 gallons which is in excess of the capacity of the present sources of supply, of Plug Pond, in a series of dry years. It therefore follows additional supply should be provided at once, or that measures be taken promptly to diminish the consumption of water.

amount of water consumed in Haverhill is very large in proportion to population, as will be seen by the following comparison with the consumption in other cities in the State where the manufacture of boots and shoes is the chief industry:—

| NAME OF CITY.                | Estimated Population in 1893. | AVERAGE DAILY CONSUMPTION OF WATER IN GALLONS, 1892-94, INCLUSIVE. |                 |
|------------------------------|-------------------------------|--------------------------------------------------------------------|-----------------|
|                              |                               | Total.                                                             | Per Inhabitant. |
| including Saugus), . . . . . | 68,378                        | 3,770,000                                                          | 55              |
| 1, . . . . .                 | 30,600                        | 2,800,000                                                          | 92              |
| . . . . .                    | 31,200                        | 767,000                                                            | 25              |
| ough,. . . . .               | 15,524                        | 441,000                                                            | 28              |

is no doubt that the consumption of water in Haverhill is unusual, and that it would be feasible to diminish it by preventing the loss and waste of water to such an extent that the present sources would supply considerably more than the present population.

Analyses of samples of water collected from the East Meadow River at the mouth of the proposed storage reservoir, together with an examination of the drainage area of this river, show that the water is practically free from pollution by sewage, but that it contains organic matter, and has a brown color derived mainly from the swamps upon the water-shed; so that, if



conveyed directly to the city, it would be less attractive in appearance and probably less palatable than the water from the present sources.

This objection would be overcome to a large extent by pumping the water into Kenoza Lake. The mingled waters will be of much better quality than the water of the East Meadow River, and will bleach and otherwise improve in quality by storage in the lake. When it becomes necessary to take a large proportion of the water from the East Meadow River, it may prove desirable to improve the quality of the water of the river by thoroughly draining the swamps upon the water-shed, so that the water will not take up so large an amount of organic and coloring matter. If the population upon the water-shed of the river should increase materially, it may be necessary to take efficient measures to prevent the waste matters from entering the river.

Owing to the large size of the water-shed of the East Meadow River above the proposed dam, there is no doubt that the quantity of water which flows in the river during the year is much larger than the quantity flowing into all of the present sources; and, since the ponds and lakes now in use have a very large storage capacity, a large additional supply could be obtained by pumping the portion of the flow of the river which could be made available without constructing a storage reservoir upon it. A still larger supply, however, can be obtained by constructing the proposed storage reservoir upon the river, and if all of the mud and vegetable matter is removed from its site, as proposed by you, the quality of the water should improve rather than deteriorate by storage in this reservoir.

As the result of all of its examinations, the Board believes that the proposed source can be made to furnish a water of satisfactory quality, and that it is the most appropriate source from which to take an additional water supply for the city of Haverhill.

**HOLDEN.** The committee on water supply for the town of Holden applied to the Board Jan. 23, 1895, for its advice relative to taking the water of Pine Hill Reservoir in that town as a source of domestic water supply. The Board replied to this application as follows:—

Boston, March 19, 1895.

The proposed source would furnish an abundant supply of water, but the quality is likely to be somewhat unsatisfactory unless the town obtains control of and improves the reservoir, which was not originally prepared with a view to storing water for domestic use, and is now drawn very low in dry seasons for use at the mills below, and improves the quality of the water entering the reservoir by preventing the discharge of manufacturing wastes into it, and by draining swamps above the reservoir.

In addition to the objection that this water is not likely to be wholly satisfactory in quality, there is the further objection that the reservoir is not high enough to furnish by gravity an efficient fire service in the town.

In view of these unfavorable features of the source proposed by you, the Board has caused a further examination of Muschopauge Pond in the town of Rutland to be made, in order to ascertain whether this source, which has recently been considered in connection with a proposed water supply for Rutland, is not also an appropriate source of supply for Holden. This pond will furnish a water of better quality than Pine Hill Reservoir, is high enough to provide by gravity an ample pressure for fire purposes in all parts of Holden, and the quantity of water is sufficient for both towns.

Measurements from the State map indicate that the additional length of a pipe required to take water from the pond instead of from Pine Hill Reservoir will be about 0.7 of a mile; but the advantages of taking a water supply from this source are so great that the Board regards it a more appropriate source for the town of Holden than the one proposed; subject, however, to the right of the town of Rutland to take as much water as it needs from the pond.

**HOLYOKE.** An application was received from the water board of Holyoke Nov. 29, 1895, for the advice of the State Board of Health, relative to a proposed additional water supply, to be taken from the south-west branch of the Manhan River at a point about one and one-half miles above Russellville.

The Board replied to this application as follows:—

Boston, Jan. 3, 1896.

The State Board of Health received from you on Nov. 22, 1895, an application with reference to a proposed additional water supply for the town of Holyoke, to be taken from the south-west branch of the Manhan River, at a point just below the confluence of the Manhan and Tucker rivers, about two and one-half miles above the village of Russellville in the town of Southampton. You propose at first to divert the natural flow of the brook through a twenty-inch or twenty-four-inch pipe into Ashley Pond, and of your present sources of supply, by gravity, and subsequently, when an increase in the use of water by the city makes necessary a larger supply than the natural flow of the brook will furnish in connection with present sources, you propose to construct storage reservoirs at favorable sites along the stream and its tributaries.

Our investigations with reference to storage reservoirs upon the watershed of the proposed source indicate that a reservoir of a capacity of about

760,000,000 can be constructed on the Manhan Brook, about one and one-half miles above its junction with Tucker Brook, and that another reservoir of large capacity can be constructed at the junction of Manhan and Tucker brooks.

The Board has caused an examination of the proposed source of supply to be made and samples of the water sent in by you to be analyzed. These analyses indicate that the water of the proposed source is soft, and otherwise of good quality for domestic use.

This water-shed, when developed by the construction of storage reservoirs at the sites indicated, will, in connection with your present sources, furnish a sufficient supply for the city for a very long time in the future at the present rate of increase in population, if the consumption of water does not exceed about 90 gallons per inhabitant.

The taking of the proposed source by Holyoke does not appear to conflict with the interests of other growing communities in the vicinity, so far as the future water supply of these places is concerned, and the source is an appropriate one for additional water supply for Holyoke.

The question as to the size of pipe to be used for conveying water from the south-west branch of the Manhan River to Ashley Lake is largely one of cost, and depends to a considerable extent upon the future growth of the city. If the city should continue to grow for many years in the future at about the same rate that its past growth seems to indicate, there will probably be little difference in the ultimate cost whether a twenty-inch or twenty-four-inch pipe is used. If the increase in population and in the use of water should be less rapid in the future than in the past, a twenty-inch pipe would probably be somewhat more economical. There is an advantage in the use of the larger pipe, however, in that, even before its full capacity is required to prevent a shortage of water, it would be of great advantage in filling the present ponds and reservoirs in the spring, keeping them at a higher level in the summer, and maintaining a better quality of water.

**KINGSTON.** In the report of the Board for 1888 the following statement appears in regard to the water supply of Kingston : —

In the town of Kingston there are at present two water supplies, one of which, supplying water for about forty or fifty families, has for many years conveyed its supply to the houses for a considerable part of the distance in a lead pipe one and one-half inches in diameter. As there was some apprehension in the town lest injury might occur to the persons using this water, it was thought best to refer the matter to the State Board of Health. It was stated that in certain instances persons who used the water had been made ill. So far as could be learned, however, the

ptoms which had been referred to this cause were not indicative of lead-poisoning.

Samples of the water were obtained from the pipes at Kingston, and submitted to chemical analysis. The result of the analysis indicated that the water was dissolving quantities of lead, so minute that they could not be regarded as injurious to health; but the fact that any lead was dissolved by this water may imply that under certain circumstances the quantity of lead contained may be large enough to become injurious, and we are glad to learn that since the date of this inquiry the works of the Water-duct Company have been bought by the town of Kingston, and the use of the lead pipe discontinued.

The public water supply of the town, after the general introduction of water and the discontinuance of the works of the old company, was obtained from a well near the mill-pond upon the Thames River. This was subsequently increased by means of a water-gallery about three hundred feet in length, extending along the bank of the pond and river above the well. In 1891 the filter-ery was still further extended to a length of about twelve hundred feet.

In August, 1895, information was received by the Board from several sources that persons using the water of the Kingston water-works exhibited well-marked symptoms of lead-poisoning. About the same time a verbal request was made by the Kingston water-works that an analysis of the water supplied by the town should be made. The Board then caused an investigation to be made, which proved conclusively that at least twenty-five of the consumers of the water of the public supply at Kingston presented undoubted symptoms of lead-poisoning.

The following conditions were also found to exist:—

1. An unusually free use of lead pipe through the town. The service-pipes were all of lead, and the average distance of the houses from the street is greater than that which prevails in most villages, so that longer pipes are necessary for supplying the houses. There are several instances in which houses are situated at an unusual distance from the street main, so that several hundred feet of lead pipe are used to connect the house with the main, and in these cases the most severe cases of lead-poisoning have occurred. In one instance, where there were long stretches of lead pipe, the water did not suffer, and in these cases it was found that care was

taken not to use the water which had remained in the pipes over night, but to let it run off before using. Samples of water were obtained from the taps at several houses, the water having been allowed to stand over night in the pipes, and in nearly every instance the amount of lead found to exist in such samples was found to be considerably beyond the limits usually regarded as dangerous to health. These amounts were found to be as high, in several instances, as  $\frac{1}{4}$ ,  $\frac{1}{3}$  and  $\frac{1}{2}$  grains per gallon.

In consequence of the results of these investigations, the Board sent the following communication to the board of water commissioners of Kingston : —

Boston, Sept. 23, 1895.

The State Board of Health has considered your request for advice in regard to the healthfulness of the present water supply of the town, and, though not having completed its investigations, it has found that the use of lead pipes in the distribution of this water has seriously injured the health of many citizens of the town, and endangers the health of all who use the water so conveyed.

The Board, therefore, recommends the immediate removal of all lead pipes in the town, wherever they are used for conveying water for domestic use, either as service pipes or as street mains.

The general subject of lead-poisoning will receive fuller attention in a later report of the Board.

LEICESTER. An application was received from the water commissioners of Leicester, Jan. 29, 1895, for the advice of the Board relative to taking the water of Asnebumskit Pond in the town of Paxton as an additional source of water supply for Leicester. The Board replied to this application as follows : —

Boston, Feb. 5, 1895.

The State Board of Health received from you on Jan. 29, 1895, an application relative to taking an additional water supply for the Leicester water supply district from Asnebumskit Pond in the town of Paxton, and on the same day received an application from the selectmen of the town of Paxton relative to taking a water supply for that town from the same source.

The examinations made by the Board lead it to conclude that the water of this pond is of suitable quality for all the purposes of a public water supply, although it would be advisable to take first the water of certain

at the southerly end of the pond to the extent of their capacity on of the better quality of the water, and to supplement the supply of the springs with water taken from the pond. The pond will furnish an ample quantity of water to meet the requirements of both communities from its situation with relation to the sources which at present supply Leicester with water by gravity and to the town of Paxton, the Board regards it as an appropriate source of water supply for both places.

LEICESTER. An application was received June 6, 1895, from the water committee of Leominster, for the advice of the Board as to an additional water supply to be obtained by constructing reservoirs upon Fall Brook in that town. The Board replied to the application as follows:—

Boston, Aug. 12, 1895.

The State Board of Health received from you on June 6, 1895, an application relative to a proposed increase in the system of water supply of the town of Leominster, and subsequently (July 10) received from your committee blue-print copies of your proposed plans, showing locations for proposed storage reservoirs on Fall Brook in the south-westerly part of the

town. The Board has caused an examination of the proposed source of supply to be made by one of its engineers, and has also caused the water of Fall Brook to be analyzed. The analyses show that the water has but little iron, is soft, and is in other respects a surface water of good quality.

In constructing the lower reservoir on Fall Brook, as indicated on the plan submitted, the capacity of all works supplying the town will be increased to 2,000,000 gallons per day in a very dry season, and possibly to 3,000,000 gallons per day at more, depending upon the amount of water lost by leakage. If the upper reservoirs indicated on the plan should be constructed, the capacity of the works would not be further increased by more than about 1,000,000 gallons per day, an amount which would meet the increasing demand of the town for only a short time after the consumption of water had reached the capacity of the original works and proposed lower reservoir. Estimates of cost have been submitted, but it seems probable that a detailed statement will show that the cost of constructing these reservoirs, or either of them, will be found too great in proportion to the increase in supply to be justified thereby to warrant the expense.

The proposed lower reservoir, according to the plan, will cover an area of 15 acres, a portion of which, amounting to 14.8 acres, consists of pasture and meadow land, the soil of which is mud or peat, extending in some places to a depth of more than 8 feet. Samples of soil collected from several test pits at different depths from 6 inches to 3 feet beneath the

surface in the swamp and meadow area indicate that the material of this area is composed very largely of organic matter.

It is understood that it is proposed to prepare the reservoir thoroughly for the storage of water by removing all the soil and vegetable matter from the area to be flowed, excepting from the swampy portions, and that these portions are to be covered with sand or gravel, or other suitable material from the sides of the reservoir.

The experience in this State where reservoirs have been thoroughly prepared for the storage of water by the removal of all of the soil and vegetable matter from the bottom and sides has been an extremely satisfactory one, and this method should be followed in the construction of the proposed reservoir wherever the depth of soil and vegetable matter is not so great as to render it very expensive. In the swampy portions of the reservoir, where the depth of peaty and vegetable matter is so great as to render it impracticable to remove it all on account of the great cost of the work, that portion of the peat around the edges of the mass where it is less than two feet deep should be removed, and all of the trees, bushes and stumps from the other portions, and the remaining swampy material covered with sand, gravel or other suitable material, free from organic matter. The covering should be sufficient to prevent the contact of the water with the mud, peat or other organic material, and a depth of one foot will probably be sufficient in all ordinary cases. The covering should be extended beyond the edges of the peaty material so as to cover them liberally.

While no reservoir in the State has been prepared in exactly this manner, it seems altogether probable that the quality of the water in the reservoir, if treated in this manner, will be satisfactory.

Investigations of the present sources of supply of Leominster show that the yield, while somewhat indefinite, owing to leakage from Morse Reservoir, is probably between 850,000 and 900,000 gallons per day in a very dry season, an amount sufficient to supply between 90 and 100 gallons per day to each inhabitant. From investigations made by your engineer it appears that the amount of water actually used in the town in a summer month when observations were made exceeded an average of 180 gallons per inhabitant per day. This is an excessive consumption, as in all the cities and towns of the State where records of the quantity of water consumed are kept, excepting the city of Boston, the amount used in the year 1893 averaged less than 100 gallons per inhabitant, and in many towns of about the same size as Leominster the consumption per inhabitant was only from 40 to 60 gallons.

The quality of the water of your present sources of supply, with the exception of Haynes Reservoir, as shown by examinations of the Board in this and previous years, is excellent. The water of Haynes Reservoir has been of bad quality in the summer in every year in which it has been ex-

red by the Board. It is understood that a portion of the area covered the reservoir was originally swamp and meadow land, and after an additional supply has been introduced an investigation of Haynes Reservoir should be made to determine whether the quality of the water cannot be improved at reasonable cost; otherwise, it is desirable that the use of the reservoir be avoided except at such seasons, if any occur, when the quality of the water is not objectionable.

**LOWELL.** The water board of Lowell applied to the Board Nov. 1894, for its advice relative to the question of extending their driven-well system in the valley of River Meadow Brook in the town of Chelmsford. The Board replied to this application as follows:—

BOSTON, May 2, 1895.

It is learned from your annual report for 1894 that the average consumption of water during that year was 6,568,170 gallons per day, of which 4,272,617 gallons were pumped from the Merrimac River and the r-gallery and filter-bed beside it, and 2,295,553 gallons from the original driven-well plant, which was first used in September, 1893.

It is understood that the first driven-well plant was put in by you in order to substitute a pure water for the river water, and not because of any deficiency in the quantity of water to be obtained by the existing works in the river; and, as you are probably aware, the State Board of Health regards the river water, when not purified by filtration, as a dangerous water to drink.

As the first driven-well plant furnished a substitute for only a portion of the water formerly taken from the river, the new plant in the town of Chelmsford is now being constructed in order to obtain a substitute for at least a portion of the water which still has to be taken directly from the river.

Many analyses have been made from time to time of samples of water collected from the first driven-well plant, and, while there has been a slight deterioration during the past year, the water is of very good quality.

The new plant in the town of Chelmsford at the present time consists of a large number of wells driven on both sides of a long suction pipe, a short distance from and parallel with the old Middlesex Canal.

Six samples of water from these wells have been analyzed by the State Board of Health, five being collected under the direction of your city engineer and one by an engineer of the State Board of Health.

The first sample, collected on Jan. 24, 1895, was in every respect an excellent water. The second and third samples, collected respectively on March 4 and 20, had, after standing, considerable color for a ground water,



and contained more iron than is desirable in a water to be used for a public water supply, but in other respects were of good quality. It is understood that these samples were collected from the southerly half of the line of wells. The fourth sample, collected on April 3, from the northerly section of wells, was colorless, contained only an insignificant amount of iron, and was of excellent quality. The fifth sample, collected April 6, from a pump drawing water from 63 wells in the northerly and southerly sections, when 20 wells in the southerly section were shut off, had a scarcely perceptible color, contained a small amount of organic matter but more than any previous sample, and three times as much iron as the fourth sample but only about one-fourth as much as the second and third samples. The sixth sample, collected April 12, from the same pump, was of the same general character as the fifth sample.

The last two samples represent a larger number of wells than the others, and the water which they supply is of very good quality at the present time, but whether it will remain so when water is pumped continuously for a long time cannot be foretold with certainty with the present information.

Experience with the ground-water supplies in the State shows that in some cases the quantity of iron has increased and the waters have deteriorated in other respects with long-continued pumping, until it has become necessary to provide a new supply. In other cases the waters have remained unchanged after as many as twenty years of continuous pumping, but there is no case which has come to the attention of the Board in which long-continued pumping has improved the quality of the water.

Both the old and the new driven wells will derive a part of their supply by the filtration of water from River Meadow Brook, upon which the main village of Chelmsford is situated; and, while the water filtering from the brook in this way may become partially or wholly purified by its passage through the ground, the water of the brook should not be polluted by turning sewage into it.

The quantity of water drawn from the first driven-well plant during the year 1894 was 35 per cent. of the total quantity supplied to the city, and during the latter part of the dry portion of the year was a smaller percentage.

Judging from the quantities of water which have been pumped from the old and new systems of wells, and a careful study of all the conditions affecting the quantity of water to be obtained from them, the Board thinks it improbable that they will furnish more than half enough ground water in the drier portions of a dry year to meet the requirements of the city of Lowell; and the Board, therefore, urges you to proceed forthwith either to purify the water taken from the river or to obtain a further supply of pure water from some adequate source.

**MONTAGUE (MILLER'S FALLS).** The water supply committee of Miller's Falls applied to the Board Jan. 22, 1895, for its advice relative to the introduction of a public water supply for the village of Miller's Falls and the settlement known as Lake Pleasant by extending the pipes of the Turner's Falls water works. The Board replied to the application as follows : —

Boston, March 1, 1895.

Analyses of the water of this lake (Lake Pleasant) have been made at intervals for several years by the State Board of Health, which show that it is very soft and of excellent quality for water-supply purposes, and, with due care to protect it from pollution from the Lake Pleasant camp ground, it should remain of good quality.

It is not practicable at this season of the year, with the large amount of snow upon the ground, to determine how much water this lake will furnish. From such information as could be obtained, however, with the aid of the topographical map of the State, it seems probable that it will furnish a sufficient quantity of water for the village now supplied and the district which it is proposed to supply from it.

In view of all the circumstances, the Board is of the opinion that the proposed source of supply is an appropriate one for the villages of Miller's Falls and Lake Pleasant.

**MONTAGUE (VILLAGE).** An application was received Feb. 6, 1895, from W. H. Nims and others of Montague, requesting the advice of the Board relative to taking the water of certain springs about one-eighth of a mile south of the village as a source of public water supply for the village of Montague. The Board replied to this application as follows : —

Boston, Feb. 28, 1895.

It is understood that the water from the springs is to be collected into a small basin and well and pumped to an open distributing reservoir.

The Board has caused an examination of the source to be made, so far as was feasible at this season of the year, and an analysis of a sample of water collected from a brook flowing from the springs, and finds the water to be soft and in other respects of excellent quality for the purposes of a public water supply. If exposed to the light in open reservoirs the water is likely to be less satisfactory to the taste than if conveyed directly from the springs to the consumer, or stored in reservoirs from which the light is excluded.

The information in the possession of the Board is not sufficiently complete to enable it to predict whether this source will supply a sufficient

quantity of water for the village in a very dry season, but the indications are that it will do so.

**PAXTON.** An application was received from the selectmen of Paxton Jan. 29, 1895, for the advice of the Board relative to taking the water of Asnebumskit Pond as a public water supply for the town. The Board replied to this application as follows : —

Boston, Feb. 5, 1895.

The State Board of Health received from you on Jan. 29, 1895, an application relative to taking a water supply for the town of Paxton from Asnebumskit Pond, which is within the limits of the town, and on the same day received an application from the water commissioners of the Leicester water supply district relative to taking an additional water supply for Leicester from the same source.

The examinations made by the Board lead it to conclude that the water of this pond is of suitable quality for all the purposes of a public water supply, although it would be advisable to take first the water of certain springs at the southerly end of the pond to the extent of their capacity on account of the better quality of the water, and to supplement the supply from these springs with water taken from the pond.

The pond will furnish a sufficient quantity of water to meet the requirements of both communities, and, from its situation with relation to the town of Paxton and to the sources which at present supply Leicester with water by gravity, the Board regards it as an appropriate source of water supply for both places.

**PEPPERELL.** An application was received Oct. 10, 1894, from the water committee of the town of Pepperell, for the advice of the Board relative to the propriety of taking water for a public water supply from any source within the limits of Pepperell or from Rocky Pond in Hollis, N. H. The Board replied to this application as follows : —

Boston, Dec. 7, 1895.

The State Board of Health received from you on Oct. 8, 1894, an application with reference to a proposed water supply for the town of Pepperell, stating that permission would be asked of the Legislature to take water from any source within the limits of the town, and possibly from Rocky Pond in Hollis, N. H., if it should be high enough to furnish a supply by gravity. Subsequently a plan was submitted, indicating as the proposed source of supply a well near the Nissitissit River and just above the mouth of Sucker Brook in Pepperell.

A copy of a report by your engineer, relative to a water supply for the town, was submitted Feb. 8, 1895, proposing as a source of supply a collecting well to be located near the junction of the Nissitissit River and Sucker Brook, where it is thought that a considerable amount of water would be obtained from natural filtration through the ground from the river. A plan, which is understood to have accompanied the report of your engineer, was furnished by you in May, 1895. This plan indicates a collecting well near the Nissitissit River, just below the mouth of Sucker Brook, and a pumping station near the brook just above Brookline Street, and approximately 900 feet from the river. It is further stated in the report of your engineer, that, when required, a second smaller collecting well can be built farther up the brook in the Sartelle meadow, and the water carried by gravity to the proposed pumping station, a distance of about 7,500 feet; and it is suggested that in the trench in which the pipe to the Sartelle well would be laid a considerable amount of ground water would no doubt be encountered, and that this could be collected and taken in a tile pipe laid with open joints to the pumping station. It is further suggested that an additional supply might be obtained from the valley of Gulf Brook, above Smith & Willoughby's Pond, and delivered to the pumping station by gravity through a pipe 8,300 feet long.

The Board has caused a careful examination of the localities mentioned to be made by one of its engineers, and samples of ground water from a spring and a test well in the vicinity of the Sartelle meadow to be analyzed. The water of these samples was found to be of good quality except for its hardness, which would render it unsatisfactory for some of the purposes of a public water supply. No opportunity was found for obtaining samples of water from the ground near the mouth of Sucker Brook or in the valley of Gulf Brook.

With regard to the quantity of water to be obtained from the ground in the vicinity of the mouth of Sucker Brook by means of a well, as proposed, it is not feasible to make a definite statement, as no tests appear to have been made here to indicate the character of the soil; but, judging from the topography and the surface indications, the outlook appears to be very unfavorable to the existence of porous material beneath the surface here of sufficient depth and extent to yield enough water for the supply of the town.

The results of investigations made by you of the character of the soil in the vicinity of Sartelle meadow in the valley of Sucker Brook, by means of test wells, indicate that porous material is found beneath the surface here, from which water can be freely pumped, but that its depth is small, being in places less than 20 feet and nowhere exceeding 30 feet. The extent of the area of porous material has not been determined.

Farther down the brook, between the Sartelle meadow and Brookline

Street, in the region through which the pipe from the proposed well in the Sartelle meadow to the pumping station would be laid, test wells indicate that the material is a fine sand, from which it cannot be expected that any very large quantity of water can be collected by means of pipes laid with open joints, as proposed.

The investigations have not been sufficient to enable the Board to advise you definitely as to the probable quantity of water to be obtained from the proposed works in the valley of Sucker Brook, but with present information the indications are that the quantity of water which these works would furnish would not be sufficient for the supply of the town in the drier portion of a dry year, after water is generally introduced, and an extension of the collecting system would be necessary.

The investigations in the valley of Gulf Brook have not been sufficient to indicate definitely the character of the soil; but, judging from the information at present available, enough water might be obtained there to furnish, in connection with the proposed works in the valley of Sucker Brook, a sufficient supply of water for the town, though an extensive collecting system might be found necessary.

The situation of Rocky Pond in Hollis, N. H., beyond the limits of Massachusetts, must be regarded as a serious disadvantage to its use as a source of water supply for Pepperell. An analysis of a sample of water indicates that it is a water of good quality, and very soft. The area of the water-shed is not definitely known, but from present information it does not seem probable that the quantity of water which this source is capable of furnishing would be sufficient to meet the needs of the town after the water shall have come into general use.

From a general examination of other sources in the vicinity of the town, it is found that the surface indications in the valley of Unquetenasasset Brook appear to be favorable to the absorption by the ground of a large portion of the water falling upon its surface; and, before deciding definitely upon a source of supply, the Board would advise that you cause an investigation of the ground in the valley of this brook to be made, to determine whether an adequate supply of soft water and of good quality in other respects can be obtained from the ground here, and the probable cost of works as compared with those proposed for taking water from the valleys of Sucker and Gulf brooks.

The Board will, upon application, advise you further with regard to this matter when you have additional information to present.

PITTSFIELD (the Onota Water Company). The Onota Water Company in Pittsfield applied to the Board March 29, 1895, for its advice relative to the introduction of water for domestic purposes for that part of Pittsfield near West Street, the proposed supply to be taken

from a source or sources in the adjacent town of Hancock. The Board replied to this application as follows : —

Boston, May 2, 1895.

The Board has caused an examination of the proposed sources to be made by one of its engineers, and a sample of water from the brook to be first used has been analyzed. This sample was collected and the examination was made at a time of year when much water from melting snow was flowing in the brooks, and it was, therefore, impracticable to judge accurately of the quantity or quality of the water during seasons of low flow.

The sample of water was found by analysis to be of excellent quality and to be soft, and, judging from the character of the water-shed, which is uninhabited, the water will be of good quality at all seasons of the year, though it will probably be harder during seasons of low flow than at the time the sample was taken.

The measurements which you have made of the dry-weather flow indicate that this source may furnish at all times an ample supply of water for the small population to be supplied from it at the present time, and, should it prove insufficient in the future, it seems feasible to enlarge the capacity of this source by building a storage reservoir or to obtain an additional supply from other brooks flowing down the easterly slope of these mountains.

The Board, therefore, regards the sources proposed by you as appropriate ones from which to take a water supply for the inhabitants of the high lands in the westerly portion of Pittsfield.

**READING.** An application was received from the water board of Reading March 15, 1894, for the advice of the State Board of Health relative to the purification of the public water supply of the town. The special points upon which information was desired, together with the reply of the Board, are indicated as follows : —

Boston, Feb. 18, 1895.

The State Board of Health received from you on March 15, 1894, an application asking for its advice with reference to a proposed system of purification for the water supply of the town of Reading, in which you state that your proposed additions are fully set forth on page 24 of your report for 1894. You further state that "The water board of Reading are anxious to ascertain from the State Board of Health : —

"*First.* — Whether the State Board has any suggestions to make as to the advisability of adopting the above system.

"*Second.* — Whether the State Board has any facts in its possession which will aid the water board of Reading in arriving at the best solution of their water troubles.

“*Third.*— Whether the State Board has any recommendations to make as to abandoning the present supply and seeking a new source.

“*Fourth.*— Whether, all things considered, the treatment in the method proposed is not the best thing that the town of Reading can do.”

About one month later the Board received from the committee on water supply of the town of Reading a communication requesting the Board to examine the territory around the source of the Mystic River, with a view to a supply for Reading from that source, and to examine Silver Lake in Wilmington for the same purpose.

This application received the attention of the experts of the Board soon after it was submitted, but, owing to the nature of the advice asked for, it was necessary to determine the probable effect of the proposed treatment of the water at times when the meadow in which the filter-gallery is situated is covered with water, which did not occur until about the 20th of October.

A very large number of examinations of the water of the filter-gallery have been made during these investigations and previously, and from these results it appears that the objectionable character of the Reading water is due chiefly to the presence at nearly all times of an excessive amount of iron, in connection with other mineral and organic matter. The amount of iron found in the water varies greatly at different times, being very large in the portion of the year when the meadow is covered with water and much smaller during the summer when the meadow is dry. It has also been observed that the quantity of iron present in the water may vary greatly in the course of a single day's pumping.

In contrast with other waters in which a sufficient amount of iron has been found to affect the appearance and quality of the water, it has been found that the iron in the Reading water is present as a sulphate instead of being in the form of bicarbonate. When iron is present as a sulphate its removal from water is very much more difficult than when it is present as a bicarbonate.

Many experiments have been made at different times, with a view to a removal of the iron by oxidation and subsequent filtration of the water through sand to remove the precipitated iron oxide. The results obtained by this means have been very variable. But in general it may be said that when the iron is present in the water in small amount, say not over 0.3 of a part per 100,000, the iron will separate out of the water almost completely on exposure to the air for twenty-four to thirty-six hours, in the form of a rusty precipitate which can be removed entirely by filtration through sand at a rapid rate. This method is substantially that proposed by Mr. Desmond Fitzgerald in his report to your board. Forced aeration by filtering through sand with a current of air was found in almost all cases to hasten the oxidation and separation of the iron oxide.

But in one case at least, when the iron was only 0.14 parts per 100,000, aeration in this way had but little effect on the iron. The failure to remove the iron in this case seemed to be connected with a considerable amount of organic matter in the water, which prevented the precipitation of the iron after oxidation.

Again, the difficulty in removing the iron appears to increase rapidly with the amount of iron in the water, and when large amounts are present, say from 1 to 2 parts per 100,000, which has been frequently the case the past winter, the means found adequate to remove the iron when present in small amounts are unavailing. Exposure to the air for two days had practically no effect on the iron contents of water of this character, and even after thorough aeration it separated out only in part, leaving most of the iron still in the water, upon which filtration had no effect.

During the progress of this investigation, advantage has been taken of the presence at the Reading pumping station of a small mechanical filter placed there and first operated about the middle of the summer. This filter consisted of two upright cylinders, one said to contain 30 inches in depth of sand, and the other 30 inches of bone-char, each having an area of about one square foot. Later in the season the number of cylinders was doubled.

Experiments with this filter showed that with iron not exceeding 0.1 of part per 100,000, rapid filtration alone without exposure to air was capable of removing practically all of the iron in the water, but when the water contained larger amounts of iron the action of the filter was uncertain. With very high iron, say 1 part per 100,000, the filter had no effect whatever on the amount of iron. No special advantage was found in the use of bone-char in these experiments, and it is, therefore, probable that any sand filter capable of being readily and thoroughly cleaned would do equally good work.

Any treatment by filtration which will remove the iron will be very likely also to remove the objectionable odor and appearance of the water.

When the amount of iron in the water was very high, experiments were made to learn whether it could be removed by chemical means, a cheap form of which would be filtration through carbonate of lime (in the form of marble chips). The experiments in this line have indicated that the iron can be completely removed by filtration through carbonate of lime, but that in this process the water takes up lime in large amount, and is made very hard. A combined process of aeration and filtration through sand and with subsequent filtration through carbonate of lime leaves the water much less hard than when it is put directly upon a filter containing marble; and the results indicate that the hardness of the water after treatment in this way could be at least 16 to 18 parts per 100,000, while the hardness of the



water after filtration through carbonate of lime, without previous aeration and filtration through sand, is likely to be at least 25 parts per 100,000.

While the hardness of the water, if treated chemically, by filtration through carbonate of lime as suggested, would be very little or no greater than that of waters supplied to some of the towns in the vicinity of Boston, the Board does not recommend the use of so hard a water for a permanent supply.

Since the higher amounts of iron and organic matter are found when the meadow is flooded, it would seem that the quality of water in these respects might be greatly improved and the water rendered more susceptible of further improvement by filtration or other treatment, if this flooding were prevented.

The artificial flooding could be prevented by keeping the gates at the dam open, but this might not prevent the flooding of the meadow during periods of very high flow in the stream; but this flooding would be of short duration, and would not affect the quality of the water nearly as much as the present flooding, which lasts for many months. The flooding could be wholly prevented by building dikes.

Examinations of the ground in the vicinity of the Ipswich River, between one and two miles above your present works, by means of test wells driven by your Board, were favorable in respect to quantity; but the water of the wells was found on analysis to contain so much iron that its quality would be likely to be unfavorably affected from this cause, if a supply should be taken from the ground in this locality. A similar examination in the water-shed of Lake Quannapowitt, south-east of the village and near the Wakefield boundary, gave similar unfavorable indications as to the quality of the ground water to be obtained in that region.

A sample of water collected from a tubular well located in the area known as the Bancroft meadow was found on analysis to be of excellent quality; but the area from which water drains toward this meadow is so small that it is improbable that any large supply of water could be drawn continuously from this source.

Other territory within the limits of the town was examined, but at no place were the surface indications sufficiently favorable to afford a reasonable expectation that a supply of water of satisfactory quality and in sufficient quantity for the supply of Reading could be obtained.

The right to a supply from Martin's Pond has already been granted to the city of Malden, and the Board has already stated, in a reply to that city (annual report for 1892, page 28), that it does not consider it feasible to obtain a satisfactory supply directly from this pond. Investigations made recently by that city with a view to taking a supply from the ground in the vicinity of this pond have been unfavorable, and at the present time

it does not seem probable that Malden will build works for taking its supply from this source.

A supply from the head-waters of the Mystic River would have to be taken above the chemical works near South Wilmington, in order to avoid danger of pollution from those works. The water-shed here is too small to furnish a sufficient supply without storage, and there appears to be no good site for a storage reservoir of sufficient size; moreover, this territory is within the Mystic water-shed, which is inadequate for the supply of the cities now supplied from it.

No investigations of the ground at this place have been made, but, owing to the small size of the water-shed, the conditions beneath the surface would need to be exceptionally favorable to obtain any considerable amount of ground water from this source.

Silver Lake, in Wilmington, has an area of about 32 acres and a very small superficial water-shed. It may, however, yield more water than is indicated by the size of its water-shed, because it is surrounded by extensive areas of sandy soil.

Judging from the surface indications and from the character of the material obtained from two test wells driven in the vicinity, it is not improbable that investigations would show that enough good water might be gained from the lake or from the ground in the vicinity of the lake or of Upper Brook, which flows very near it, to supply Reading and Wilmington; but the amount and quality of the water can only be determined with certainty after the ground has been thoroughly tested and samples of the water examined.

As you are aware, the State Board of Health has recently submitted to the Legislature a report upon a general system of water supply for the metropolitan district about Boston; and, while Reading is situated outside the ten-mile limit referred to in the act under which this report was made, there seems to be no reason why it may not be included among the places to which this supply is to be furnished.

No data are at hand upon which to base a definite estimate of the probable cost of works for the supply of Reading from Silver Lake; but the likely cost of obtaining a supply from this source would probably exceed considerably the cost of a supply as a part of the metropolitan water district.

With its present information, the Board advises the town of Reading to take measures to obtain its future supply as a part of the metropolitan water district, and to abandon its present source when the new supply becomes available. In the mean time, provision should be made to improve the present supply by preventing the flooding of the meadow over the outfall-gallery, and it may be advisable to adopt, temporarily, some system of filtering the water rapidly through sand.

**RUTLAND.** The committee on water supply of the town of Rutland applied to the Board Dec. 24, 1894, for its advice relative to taking the water of Lake Muschopauge in that town as a source of water supply for the town. The Board replied to this application as follows : —

Boston, Feb. 23, 1895.

The examinations made by the Board lead it to conclude that this pond will furnish a sufficient quantity of water of suitable quality for all the purposes of a public water supply, and that it is, therefore, an appropriate source of supply for the town.

**SHEFFIELD.** H. S. Andrews and others of Sheffield applied to the Board Nov. 20, 1894, for its advice relative to taking the water of certain springs in that town, about two and one-half miles north-east of the village, as a public water supply for Sheffield. The Board replied as follows : —

Boston, Feb. 23, 1895.

It is understood that it is proposed to intercept the flow from springs, and to store the water in small reservoirs from which it will flow by gravity to the portions of the town to be supplied.

The samples of water collected from the springs early in January, 1895, have been found by analysis to be very soft, and of excellent quality for the purposes of a public water supply. If exposed to the light in open reservoirs the water is likely to be less satisfactory to the taste than if conveyed directly from the springs to the consumer, or stored in reservoirs from which the light is excluded.

With regard to the quantity of water, it is not feasible to tell with certainty from the present information whether or not a sufficient supply can be obtained from the springs, but the prospects are favorable ; and, if the supply should prove insufficient during a portion of the year, it appears probable that it might be supplemented from a small brook which flows near the springs, by constructing a storage reservoir upon it above them.

The Board regards this source as an appropriate one from which to take a supply of water for the town.

**SHIRLEY.** An application was received Nov. 5, 1895, from the selectmen and committee on water supply of the town of Shirley, for the advice of the Board relative to taking water from Leatherboard Pond in that town as a public water supply. The Board replied to this application as follows : —

Boston, Dec. 5, 1895.

The quantity of water which the proposed source is capable of furnishing is ample for the use of the inhabitants of the town of Shirley. With regard to quality, however, the water of this source would be very unsatisfactory, owing to its high color and unpleasant odor, as indicated by a sample collected Nov. 13, 1895, due to its contact with vegetable matter in the large swampy area within the water-shed of Bow Brook above the point where it enters the pond. The character of the pond itself, moreover, is not such as to influence favorably the quality of the water, as it is very shallow, and the bottom appears to be covered in places with mud and vegetable matter. The quality of the water may also be greatly influenced from time to time by the condition of the water in Fort Pond, situated near the upper end of the water-shed of the brook. This pond is used as a storage reservoir, and its water is drawn off during the drier portion of the year through Leatherboard Pond, to assist in maintaining the flow of the stream below. A sample of water, collected from Fort Pond November 13, contained a very large number of organisms, mostly of a kind which is liable to produce offensive tastes and odors, and this water in its present condition would be very unsatisfactory for domestic purposes. It is not feasible to tell whether the water at the present time is better or worse than at other seasons of the year, but it may be said that as a rule the quality of the water of ponds is worse in summer.

In view of the poor quality of the water of Leatherboard Pond and the unfavorable character of its water-shed, the Board does not advise its adoption as a source of water supply for the town of Shirley.

While the Board is not fully informed as to the feasibility of obtaining a satisfactory supply from some other surface source in the vicinity of Shirley Village, it seems probable, with present information, that a ground-water supply of good quality, if such a one can be obtained, would be more satisfactory for the town than any surface-water source in the vicinity; and the Board advises that it is desirable in making further investigations for a water supply, to determine the feasibility of obtaining a satisfactory supply in this way, but cannot with present information advise definitely as to the place for making investigations.

The Board will, upon application, advise you further in this matter when it has the results of further investigations to present.

STOUGHTON. An application was received from the Stoughton Water Board Jan. 16, 1895, for the advice of the Board relative to producing a supplementary supply of water, in accordance with the methods and plans presented by their engineer. To this application the Board replied as follows:—

BOSTON, April 4, 1895.

One of these plans provides for collecting the water of the springs which outflow at the edge of the low land surrounding Muddy Pond, and is, in its general features, the plan recommended by the State Board of Health in its communication to you dated Oct. 13, 1893, a copy of which is enclosed herewith. The other plan provides for taking water from a well located about 1,150 feet above the present pumping station, on a point of land at the junction of Muddy Brook and the brook flowing from Stoughton village.

In choosing between these two plans, the most important features are, obviously, the quantity and quality of water which they will furnish.

With regard to the quantity of water which the first plan will furnish, it may be said that the communication above referred to stated that the total flow of the springs, as represented by the outflow from Muddy Pond on April 26, 1892, was 1,410,000 gallons per day, and on Sept. 11, 1893, fully 1,000,000 gallons per day. Measurements made under the direction of your engineer from Sept. 24 to Oct. 4, 1894, show that the flow ranged from 435,000 to about 900,000 gallons per day. A measurement made on March 15, 1895, showed that the amount was upwards of 1,500,000 gallons per day. The lowest of the above quantities is considerably more than enough for the present population of the town, with any ordinary rate of consumption of water per inhabitant; but it is enough smaller than the other measurements to indicate the possibility, under extreme conditions, of an insufficient flow from the springs, making it necessary to have recourse to some surface-water or other supplementary source at such time. Of the excellence of the water to be obtained from this source there is no doubt, provided it is intercepted, as advised in the last communication, before the water has been exposed to the light or come in contact with the vegetable matter in the swamp surrounding the pond.

The tests made near the site of the well proposed by the second plan show that there is a thick layer of porous gravel underlying the fine sand found for a considerable distance down from the surface, and from the gravel water can be pumped very freely. Judging from the freedom with which the water can be pumped from several of the test wells, there seems to be no doubt that when the ground is full of water a well or wells at this place will furnish it at a rate sufficient for the supply of the town, and the question of a supply from this source depends mainly upon whether there will be a gradual lowering of the water in the ground during dry seasons, with a corresponding diminution in the amount of water which can be pumped from the well.

From all the information now available, it seems probable that the springs at Muddy Pond will furnish more water both in wet and in dry seasons than the proposed well.

ample of water collected from one of the test wells near the site of proposed well was analyzed and found to be of excellent quality, but sample does not necessarily indicate the quality of the water to be obtained by continuous pumping from the well. It does not seem at all probable that the well will furnish a sufficient quantity for the supply of the town unless the water in it is drawn below the level of the adjacent millpond and a considerable amount of water filters from this millpond and seeps further up the stream coming from the village to maintain the level of the ground about the well. The water filtering in this manner is thoroughly purified by its passage through the ground to the well; this is somewhat uncertain, and the filtration would not soften the water of this stream, which is hard, owing to its pollution. For both of these reasons the water to be obtained from the well must be regarded as inferior in quality to the unpolluted spring water.

If the plan for taking water from the springs were to be adopted, it would be desirable, unless an abundant supply of water was developed by extending a pipe to the point indicated by your engineer, to extend it still farther, so as to intercept the springs entering the pond from the easterly side and throughout the territory where the springs outflow it is desirable that the line of the pipe should be moved in toward the foot of the high ground, by so doing quicksand and mud can be avoided, and the trench dug in a more porous, gravelly material. It would also be advisable, as suggested in the last communication, to lay smaller branch pipes to tap the spring water at the places where it outflows in the greatest quantity.

In addition to the proposed well, the plan recommended by your engineer is for the construction of a small reservoir just above the Southworth mill now owned by the town, on Muddy Brook, which would have some value particularly when first constructed, upon the amount of water to be obtained from the proposed well, and the reservoir is also intended as a secondary source from which to take water directly if the supply from the well should prove insufficient. If the supply were to be taken from the springs, the pipe leading from them would pass near and below the level of the Mill Pond, from which water might be taken in a very dry time if the supply from the springs should prove insufficient; or, if it should be deemed desirable to have a large quantity of water in reserve near the pumping station, such a reserve could be provided in connection with the plan for taking water from the springs as well as in connection with the other plan. Reference is also made in the report of your engineer to the expediency of procuring a supplementary or an independent supply of water from Knowles

Owing to the fact that your pumping station is located in the valley of Muddy Brook, and the probability that a larger supplementary supply of excellent water can be obtained from the valley of this brook

than from Knowles Brook, it seems clearly undesirable at the present time to take the additional supply from the latter source.

**WALPOLE.** The water commissioners of Walpole applied to the Board March 29, 1895, for its advice relative to the introduction of a public water supply from the ground in the valley of Low Brook, about one-half mile above its junction with the Neponset River. The Board replied as follows : —

Boston, June 7, 1895.

The subject of a water supply for Walpole was brought to the attention of this Board by an application of the committee on water supply of the town in 1893, and the Board on June 5 of that year made the following reply : —

“ The investigations made near the Neponset River, not very far above the Blackburn water privilege and just below Low Brook, showed very satisfactory results as regards the porosity of the material, the freedom with which water could be pumped from the test wells and the quality of the water. Taking these results in connection with an examination of the surrounding territory and the size of the streams, the Board finds no reason to doubt that an ample supply of excellent water can be obtained from a well or wells located in the porous material in this vicinity.”

Judging from the tests which you have made by driving wells and pumping from them at the source now proposed in the valley of Low Brook, the results at this place are also very satisfactory as regards the porosity of the material and the freedom with which water could be pumped from test wells, and analyses show that the water is of excellent quality. The watershed and streams which must be depended upon for maintaining the saturation of the ground at the new location are much smaller than at the former one near the Neponset River, and, judging from all of the information at present available, the source near the Neponset River would be likely to furnish the larger quantity of water. It is not improbable, however, that wells at the new location would supply the town with all of the water required for ordinary water supply purposes for several years; but if, as has been suggested, large quantities of water are to be supplied for manufacturing purposes, the source now proposed would probably prove inadequate.

There is uncertainty, in nearly all cases where water is to be taken from a ground-water source, as to just how much water the source will furnish at the end of a long-continued drought; and, as it is very desirable that you should obtain as large a quantity of ground water as possible, the Board advises you, before finally locating your wells and pumping station, to make further investigations, with the aid of an engineer skilled in the

ction of ground-water supplies, having in view the location of the works be place where the largest quantity of water of satisfactory quality can obtained, either from the original works or from extensions to be made sequently.

VENHAM. An application was received from the selectmen of nham, Feb. 18, 1895, for the advice of the Board relative to ing the water of Pleasant Pond in that town as a source of public er supply. The Board replied to this application as follows: —

Boston, March 25, 1895.

he Board has caused an examination of this source and an analysis of mple of water collected from the pond near its outlet to be made. s pond will furnish an abundant supply of water for your town, and the er is of fair quality, but not as good as it is desirable to introduce into town if a better water can be obtained.

he unsatisfactory character of the water is due to the surface drainage n the streets in a portion of the village, the drainage from a small mp south of the main street and much larger swampy areas south of pond, and the percolation of polluted waste water from a portion of village through the ground into the pond or its feeders.

as suggested by one of your board that most of the street wash e referred to, and the drainage from the small swamp south of the t street, might be diverted from the pond and made to flow in a south-direction to Miles River; and this would have a tendency to improve quality of the pond water, but it would not be likely to make enough ge in the quality to make the water wholly satisfactory.

a public water supply were introduced from any source, without at ame time providing a system of sewers, there would be more polluted e water turned into the ground than at present, and more would find ay by percolation or otherwise into Pleasant Pond. These waters, if thoroughly purified by percolation through the ground so that they l not be dangerous to health, contain soluble matters which would ote the growth of the minute organisms which frequently give waters l in ponds and reservoirs a disagreeable taste and odor.

s possible that investigations may show that a water which is entirely actory in quality can be obtained from the ground near the pond, or some other ground-water source within the limits of the town. The

also calls attention to the fact that the pumping stations of the water of Beverly and Salem are but little more than a mile and a half from tre of Wenham village; and if arrangements could be made whereby ities or either of them would furnish water at a small advance upon



its cost, the water would probably cost the town of Wenham much less than if obtained by the construction of independent works.

The Board will advise you further in this matter, if you so desire, when you have further information to present for its consideration.

**WESTFIELD.** The committee on additional water supply of the town of Westfield applied to the Board Jan. 28, 1895, for the advice of the Board relative to the taking of Munn Brook in Granville at a point near its junction with Tillotson's Brook, as an additional source of water supply for Westfield. The Board replied to this application as follows : —

Boston, Feb. 6, 1895.

The water commissioners of the city of Holyoke applied to this Board on June 13, 1893, and again on Jan. 18, 1894, for its advice relative to taking an additional water supply from this source, and the replies of the Board to these applications are transmitted herewith. You will find in them the opinion of the Board with regard to the quality of the water so far as it has information up to the present time.

The city of Holyoke is in urgent need of an additional water supply, and the Board has in one of the replies expressed the opinion, which it still holds, that Munn Brook is the most appropriate source from which to take an additional water supply for the city of Holyoke; but the Board also believes that the brook is an appropriate source of additional supply for the town of Westfield, provided it is taken jointly by the two communities. The construction of works for the joint supply of the two communities would materially lessen the cost to each, if arrangements were made for an equitable division of their cost; and, although the capacity of the source would be reached sooner if it were used by the two communities than by either one, it will continue, with proper development by the construction of storage reservoirs, to supply both for a considerable time, and the supply can be supplemented from the Westfield Little River in the future if the supply from Munn Brook should prove insufficient.

The Board, therefore, advises you to consider the question of obtaining an additional supply from this source in connection with the city of Holyoke.

**WESTON.** Charles H. Fiske and others, petitioners for incorporation as the Weston Water and Electric Company, applied to the Board April 30, 1895, for its advice relative to taking a water supply for the town of Weston from springs in the neighborhood of Central Avenue in that town. The Board replied to this application as follows : —

Boston, Aug. 2, 1895.

The analysis of water from the test wells nearest Central Avenue showed it had at some time been polluted and subsequently well purified by its passage through the ground, while the analysis of the water of one of the wells on the farther side of the meadow from Central Avenue showed only a slight trace of previous pollution and a very thorough purification of the water by its passage through the ground. This water, as it came from the ground, except for a slight turbidity which would disappear after the wells were in constant use, was of excellent quality for all the purposes of a public water supply; but it is not improbable that the continuous draught of water from the ground at this place would cause the water which stands upon the meadow to filter downward, thereby making the water less attractive and palatable, and causing it to take up enough iron to render it unsuitable for drinking purposes.

The Board, therefore, advises you, before putting in works in this vicinity, to make further tests by driving wells in the low, sandy land lying between the meadow and the railroad; and, if these tests should show the existence of pervious material from which water of good quality can be pumped freely to a depth of 25 feet or more below the level of the meadow, it would then be advisable to locate the wells in the hard ground far from the meadow as possible, as the water obtained in this way would be much less likely to deteriorate than if the wells were sunk in the saturated meadow.

The Board will advise you further in this matter, if you so request, after additional tests have been made.

**WILLIAMSTOWN.** The Williamstown Water Company applied to the Board Sept. 16, 1895, for its advice relative to taking Flora en Brook as an additional source of water supply for that town. The Board replied to this application as follows:—

Boston, Oct. 23, 1895.

The Board has caused the proposed source of supply to be examined by one of its engineers, and a sample of the water to be analyzed. The analysis indicates that the quality of the water is excellent, and its hardness much less than that of the water of Sherman Spring and only about one-third of that of the water of Cold Spring, your present sources of supply. With the amount of storage proposed, a large addition to your present supply can be obtained from this brook, and, with properly prepared reservoirs, the quality of this water is likely to be more satisfactory to consumers than the water of either of the two springs now used as sources of supply, on account of its comparative softness.

It is improbable that your present and proposed works together will furnish as much water as ought to be provided for a growing town like Williamstown; and the development of small sources, that are likely to prove inadequate in a very few years if the town continues to grow, or if there should be a large increase in the use of water, is not in the interest of true economy. The Board would, therefore, advise that, before making further additions to the works, you have a thorough investigation made, with a view to determining the best source for the permanent supply of the town.

**WINCHENDON.** The committee on water supply of Winchendon applied to the Board Jan. 31, 1895, for further advice in regard to the Prentiss meadow in that town as a source of water supply for the town. The Board replied to this application as follows: —

Boston, May 15, 1895.

The State Board of Health received from you an application dated Jan. 31, 1895, for further advice with regard to the Prentiss meadow as a source of water supply for your town, and with this application you have submitted a report of your engineer, giving the results of certain pumping tests and investigations which have been made in order to determine the capacity of this source.

The water supply of Winchendon has been the subject of careful consideration by this Board on several occasions, and your attention is again called to the replies made by the Board to your committee on February 17, April 6, August 3 and September 10 of last year, for a general consideration of the subject of the water supply for your town and an extended consideration of the Prentiss meadow source, concerning which you now ask further advice.

Before referring to the reconsideration of the subject with the aid of the new information furnished, it may be well to state that the reply of the Board, dated Sept. 10, 1894, after referring to a method of estimating the quantity of water to be obtained from a ground water source, stated: "Upon this basis the engineers of the Board have estimated that a well or wells in the Prentiss meadows would yield during the driest four months of a dry year about 130,000 gallons per day." Again, after calling attention to the fact that the capacity of a ground-water supply cannot be determined with nearly as much accuracy as of a surface-water supply, the further statement was made: "While, therefore, the Board estimates that the quantity of water to be obtained from a well or group of wells in the Prentiss meadow would be from 100,000 to 200,000 gallons per day, it cannot be at all definitely stated that the quantity may not be even more or less than these figures."

From the information contained in Mr. Fuller's report and additional

on furnished directly by him, it is learned that one test was made day and night for thirty-seven days, from a well about 20 feet about 8 or 9 feet in diameter at the bottom. This test began on and ended on Oct. 10, 1894. During rather more than the first test no measurements of the quantity of water pumped are but it is stated that the flow was probably somewhat more than during fourteen days when the measurements were taken. The water was kept pumped down to within one foot and nine inches of the bottom of the well, so that the quantity pumped represented substantially the water which the well would furnish. The average quantity pumped per day during the last fourteen days was 271,000 gallons, and there was a gradual lowering of the water in the ground in the vicinity of the well.

A second test was made by pumping for seventeen days, from Dec. 19, Jan. 4, 1895, from ten driven wells, the nearest of which was 100 feet from the dug well, and during the last three and a half days at least water was also pumped from the dug well. The amount of water pumped from the driven wells averaged 245,000 gallons per day, but there was a very large reduction in the quantity pumped per day during the last few days of the test. The dug well supplied an average of 296,000 gallons per day during three and a half days, but even in this short time there was a noticeable reduction in the amount of water pumped. At the end of this test the water in the dug well rose to its normal level more slowly than after the first one.

In interpreting the results of these tests, it is necessary to take into account the rainfall at and before the time when they were made and the condition of the year as affecting the proportion of the rainfall, which was able to soak into the ground and aid in maintaining the supply during the

interim. The rainfall at Winchendon during the first test, as reported by the Bureau, was 8.66 inches, and during the second test 1.26 inches. The rainfall during the last four months of the year, as compared with the rainfall in Massachusetts during the same months and with the rainfall in a very dry year, is given in the following table:—

| MONTH.          | Rainfall at Winchendon, 1894 (Inches). | Average Rainfall in Massachusetts (Inches). | Rainfall in a Very Dry Year (Inches). |
|-----------------|----------------------------------------|---------------------------------------------|---------------------------------------|
| Feb. . . . .    | 7.09                                   | 3.81                                        | 1.60                                  |
| Mar. . . . .    | 2.63                                   | 3.87                                        | 3.74                                  |
| Apr. . . . .    | 2.06                                   | 3.96                                        | 1.78                                  |
| May . . . . .   | 3.25                                   | 3.57                                        | 2.83                                  |
| Total . . . . . | 15.03                                  | 14.71                                       | 9.95                                  |

The table shows that the tests were made during months when the rainfall was, on the whole, slightly above the average. The season of the year also has an important bearing, because during the warmer months the greater part of the rain which falls goes off again into the air by evaporation, while in the cooler months of the year, until the ground is solidly frozen, a much larger proportion remains to soak into the ground. A large allowance, therefore, has to be made, in order to insure an unfailing supply, to offset the diminished yield during seasons of lower rainfall and during the warmer portions of the year when more water evaporates. It should also be noted that, even during the season of comparatively large yield when the tests were made, the water in the ground continued to lower, and with continuous pumping for a much longer time it is probable that the wells would have yielded less water than they did during these comparatively short tests.

The estimates of the capacity of a well or wells at this place, as formerly made by the engineers of this Board, related to the yield during the driest four months of a dry year, and were based in part upon the exhaustion by long-continued pumping of the water stored in the ground in the vicinity of the wells; and, now that the tests have been made, we are unable to conclude that the quantity of water obtainable under these conditions would exceed the amount originally estimated, — an amount too small to supply the town after water shall have begun to be generally used.

Your engineer suggests in his report that the ground surrounding the wells may be kept saturated by introducing water from the river by means of drain pipes with open joints, placed as much as 100 feet from the wells. The Board regards this method of supplementing the supply as an impracticable one, mainly because the matters strained out of the river water would accumulate where the water passes from the joints of the pipe into the ground; and, as they could not be removed, the filter would before long become clogged and inoperative.

The Board, in its former investigation of this subject, considered various methods of extending the collecting system and maintaining the saturation of the ground by water taken from the river, and, after indicating methods which might be adopted, made the following statement: —

“Taking into account the first cost of this complicated system of works, the yearly cost of operating them in such a way as to obtain a sufficient supply of good water and the uncertainty as to the results which would be obtained, it does not seem advisable to adopt this plan, when you may obtain from Upper Naukeag Pond, by a simple plan and probably with a much smaller annual cost, an ample supply of water of good quality.”

Since the Board, after a careful consideration of all of the information furnished by your extended investigations, does not have occasion to modify its former estimates as to the probable capacity of a well or wells

the Prentiss meadow, or to change its conclusions with regard to supplementing the supply to be obtained from the ground at this place, it has no occasion to modify the advice already given to you with regard to this source of water supply.

All of the analyses of water from Upper Naukeag Pond show it to be of better quality for water-supply purposes than the water usually obtained from ponds. Six years ago the water had a disagreeable odor, such as has been found occasionally in nearly all of the surface-water supplies of the State, including some of the best ponds; but this odor, though disagreeable, is not known to be injurious to health. No trace of the odor has been found in the water of Upper Naukeag Pond for six years; and, with the results of your investigations in view, the Board is unable to advise that there is within your reach any other source as desirable as this.

In response to the request contained in a communication dated March 6, 1895, the Board sends herewith analyses of samples of water collected from different sources near Winchendon during the past year, with a brief statement of the quality of the water from each source, as indicated by the analyses.

The analyses sent included four from upper Naukeag Pond, — Nos. 12095, 792, 13813, 14122; two from Prentiss meadow, — No. 12188, driven well No. 3, No. 13092, dug well; one from Miller's River, opposite Prentiss meadow, No. 12187; one from Beaman Brook, No. 12094.

These analyses show that the waters of Upper Naukeag Pond and the wells in the Prentiss meadow are soft and of excellent quality for all the purposes of a public water supply.

The waters of Miller's River opposite the wells and of Beaman Brook have a deep brownish color, such as water acquires from contact with vegetable matter in swampy places, contain considerable organic matter, and would not be of satisfactory quality for drinking and some other water supply purposes.

**WORCESTER.** An application was received Feb. 21, 1895, from the mayor of Worcester, for the advice of the Board relative to the condition of the water of Kettle Brook to the existing water supply of the city. The Board replied to this application as follows: —

Boston, March 2, 1895.

The State Board of Health received from you Feb. 21, 1895, an application for its advice relative to the proposed additional water supply for the city of Worcester, to be obtained from Kettle Brook, at or near Kent's Falls, and diverted into the existing Lynde Brook Reservoir, from which the high-service supply of the city is now taken.

The Board has caused examinations of this brook to be made and samples of water from it to be analyzed, and it finds that the water as it now runs in the stream is of fair quality and likely to be as good after storage in the Lynde Brook Reservoir as the water now supplied to the city from that source. The water can be improved, however, by ceasing to use the Arnold Reservoir, which floods a swampy territory near the head of Kettle Brook to a small depth, by draining this swampy territory and by other methods of improving the quality of the water which will suggest themselves to your engineers.

This brook will furnish by gravity a substantial addition to the present supply of your city at a very small cost for engineering works, and the Board regards it as an appropriate source from which to take the next addition to the water supply of your city.

WRENTHAM (PLAINVILLE). An application was received Jan. 8, 1895, from H. G. Bacon and other citizens of Plainville in Wrentham, for the advice of the Board relative to taking the water of Ten Mile River, at some point above Plainville, to which the Board replied as follows: —

Boston, Feb. 5, 1895.

The State Board of Health received from you on Jan. 8, 1895, an application for advice relative to a proposed water supply for a part of the town of Wrentham, in which you state that it is your intention to introduce a system of water supply in the village of Plainville in the town of Wrentham, and, for the purpose of carrying out such a plan, a petition will be presented to the General Court. You ask for advice upon the proposed plan to take the water of Ten Mile River at some point between the village of Plainville and the head of Ten Mile River.

The Board, under date of Dec. 20, 1894, advised the board of water commissioners of the town of North Attleborough with regard to the Ten Mile River above the village of Plainville as a source of water supply for the town of North Attleborough and the village of Plainville. In the communication to North Attleborough (a copy of which is published in the twenty-sixth annual report of the State Board of Health, 1894, page 35), you will find the opinion of the Board with regard to the quality of the water; also its opinion as to the propriety of taking water from this source for the supply for the village of Plainville, as well as for a supply for the town of North Attleborough.

#### SEWERAGE AND SEWAGE DISPOSAL.

The following is the substance of the action of the Board during 1895, in reply to applications for advice relative to sewerage and sewage disposal: —

**AMESBURY.** An application was received from the committee on sewerage of the town of Amesbury Nov. 2, 1894, for the advice of the Board relative to the sewage disposal of Amesbury, having proposed outlets into the Powow River. The Board replied to this application as follows : —

Boston, Feb. 12, 1895.

The State Board of Health received from you an application dated Nov. 1894, in which you ask its advice with regard to the disposal of the sewage of Amesbury, and with this application you submit certain plans made several years ago and suggest that they will require some modification.

The Board advises that you have the whole subject re-examined and plans prepared for discharging the sewage into the Merrimack River, and that you adopt a plan for disposing of the sewage in this manner, if it is found practicable to do so. If, however, you find that the cost is too great to warrant the adoption of the complete plan at the present time, it is permissible to discharge temporarily into the Powow River at or below the mouth of Patten's Brook as much sewage as will be furnished by a population of 5,000, but the outlet pipe should be extended to deep water, so as to avoid fouling the shores.

**ANDOVER.** An application, submitting certain specific questions, was received from the sewer commissioners of Andover, Aug. 1, 1895, for the advice of the Board relative to two plans of sewerage and sewage disposal for that town. The Board replied to this application as follows : —

Boston, Oct. 10, 1895.

The State Board of Health received from you on Aug. 1, 1895, an application with reference to the disposal of the sewage of the town of Andover, containing the following statement as to your proposed plans : —

“The town of Andover submits two plans for the disposal of its sewage : —

- ‘1. Above the stone bridge, six hundred feet from Main Street, to erect a building, 114 by 42 feet (A), with two sets of double collecting tanks and two filter-beds, thoroughly underdrained, within the building, filtered through a 4-foot chimney 75 feet high, the effluent to have intermittent filtration out of doors through 2½ acres of prepared filter-beds, underdrained, with 3 feet of sand covered with 3 inches of loam, receiving sewage from overdrains, the whole draining into the Shawsheen River.
- ‘2. Such a building (B) on the river below Frye Village without outdoor filter-beds, emptying directly into the Shawsheen River.



"3. Will the Board suggest the size of out-of-door filter-beds deemed necessary to make acceptable our second plant?

"4. Can loam be used over the sand in filter-beds?"

The application was accompanied by plans of the proposed plant at the location first indicated, which is an area of low ground bordering on the right or easterly bank of the Shawsheen River, between Main Street, Harding Street and the Boston & Maine Railroad; and subsequently a report was submitted relating to the proposed method of operation of the plant, and a sample of the sand intended to be used.

The essential features of the plan are settling tanks for the removal of the suspended matters from the sewage by sedimentation; filter-beds having an area of 2,800 square feet, and containing about 5 feet in depth of filtering material, through which it is expected to filter sewage from the settling tanks intermittently at a rate of 3,200,000 gallons per acre daily; and a secondary filter-bed, having an area of 2.3 acres, to be used for the filtration of the effluent from the first-mentioned filters by application to sand beneath a layer of loam. By the alternative plan, the last-mentioned filter-bed may be omitted, but the effluent in either case would be discharged into the Shawsheen River.

The Board has carefully considered the proposed scheme, and finds that it is a thoroughly impracticable one for the disposal of the sewage of the town of Andover.

The settling tanks into which the sewage would be discharged as it came from the main sewer cannot be expected to remove more than a very small portion of the suspended matter. Experiments at Lawrence with reference to the removal of organic matter from sewage by sedimentation have shown that by allowing sewage to settle for four hours about 18 per cent. of the organic matter, as indicated by the albuminoid ammonia, was removed. The consumption of water in Andover for the year 1894 averaged 323,000 gallons per day, and it is not unreasonable to expect that the amount of sewage to be disposed of after the sewerage system has come into general use may be in the vicinity of 200,000 gallons per day. With this quantity of sewage flowing, the time occupied by it in passing through the proposed settling tanks would not average more than two hours, or about one-half the time allowed in the experiments at Lawrence, and during the portion of the day when the flow was greatest the sewage would pass through the tanks in less time; moreover, there would be a constant flow of sewage through the proposed tanks, while in the case of the experiments at Lawrence the liquid was not disturbed.

The in-door filter-beds for the rapid filtration of the sewage after it has passed through the settling tanks are altogether inadequate for the purpose, and would very quickly become clogged, so that the required quantity of sewage could not be made to pass through them.

The proposed rate of filtration for these filters (3,200,000 gallons per acre per day) very greatly exceeds the highest rate ever attained in the filtration of sewage through any sand or gravel in the experiments at Lawrence with the most favorable conditions, even with sewage from which the greater portion of the organic matter had previously been removed; and it may be added that it exceeds even the rate at which Merrimack River water is filtered through the Lawrence city filter.

The effect of applying sewage to the proposed filter at such an excessive rate would be that no opportunity would be allowed for nitrification to become established in the filter, whereby the organic matters would be converted into mineral matters and pass out in the effluent, and the organic matters would consequently accumulate in the interstices of the sand and clog the filter, even if its surface was continually disturbed or scraped.

The purification of sewage by intermittent filtration is not merely mechanical; that is, it is not a straining through fine pores, thereby holding back the organic matters in the sewage, but it is a chemical change, in which the substances are converted into mineral matter, which passes off easily in the purified liquid. To effect this change the experiments at Lawrence have clearly shown that the necessary conditions are very slow motion of very thin films of liquid over the surface of particles having spaces between them sufficient to allow air to be in contact with the films of liquid. With these conditions it is essential that certain bacteria should be present to aid in the process of nitrification; and it has been found that these bacteria come in the sewage at all seasons of the year, and the conditions mentioned appear to be the most favorable for their efficient action.

The proposed filtration area outside the building, to which sewage is to be applied by carriers laid beneath a surface layer of loam, would, on account of the limited capacity of the proposed in-door filters for purifying sewage, receive sewage from which only a small proportion of the organic matter had been removed. While no special chemical or biological difficulties attend the purification of sewage by this form of filter, it has been found both by experiment and in practice that the carriers become clogged with organic matter so that it is necessary to dig up, clean and replace them from time to time, making the cost of maintenance of such a filter greater than where no loam layer is used and sewage is applied directly to the surface of the sand; moreover, experiments with two filters containing the same kind of sand, at Lawrence, to one of which sewage was applied upon the exposed surface of the sand and to the other beneath a layer of loam, was found that the amount of sewage that could be disposed of by the former was more than twice as great as by the latter.

Finally, if sewage should be filtered through properly prepared beds of sand, such as are proposed for use in the filters under consideration, at a rate which will not overtax the capacity of the filter, the effluent would be

sufficiently purified to permit of its discharge directly into the Shawsheen River without further treatment. It may be added that an area of about six acres of such filter-beds would be sufficient for the town in the beginning, but it would be desirable to provide for increasing the area when necessary.

**BROCKTON.** An application was received Aug. 16, 1895, from the mayor of Brockton, for the advice of the Board relative to a proposed plan of "surface drainage" in the Cabot Street section of that city. The Board replied to this application as follows:—

Boston, Oct. 3, 1895.

The State Board of Health has carefully considered the plan for proposed drainage of the Cabot Street system which you presented for its approval August 5, under the provisions of chapter 309 of the Acts of 1888, and hereby approves said drainage system.

**DANVERS.** An application was received Nov. 4, 1895, from the board of health of the town of Danvers, for the advice of the Board relative to the disposal of the sewage of certain morocco factories now discharging into Crane's River in that town by conveying it to an outlet at Danversport. The Board replied to this application as follows:—

Boston, Dec. 5, 1895.

The State Board of Health has carefully considered your application for advice with reference to disposing of the nuisance in Crane's River caused by the discharge into it of manufacturing sewage from three morocco shops. The plan accompanying your application is to divert the sewage from the brook into which it flows at present, and convey it by means of a sewer to a point of discharge in the channel of the Essex Branch River, a tidal stream, near its junction with Crane's River, and you express a doubt as to whether this method of disposal would be satisfactory.

The proposed outlet is close to the village of Danversport, and it appears that there are very extensive flats in the vicinity, which are exposed at low tide. An analysis of a sample of the sewage, collected as it flowed from the present settling tank, shows that the sewage contains several times as much organic matter as is found in ordinary town sewage, and that a large proportion of it is in suspension. With the conditions existing in the vicinity of the proposed outlet, it is probable that organic matter from the sewage would collect on the flats, and cause a nuisance similar to that now existing in Crane's River. The Board does not, therefore, advise the adoption of this method of disposing of the sewage, and it may be added that there appears to be no body of water in the immediate vicinity of the town into which the sewage could be discharged without offence.

It is probable that the sewage from the establishments in question might be disposed of in connection with a general system of sewerage and sewage disposal for the thickly settled portion of the town; and it is suggested that, when a demand arises for such a system, as will doubtless be the case should the town continue to increase in population, it may be found most economical and otherwise satisfactory to dispose of the sewage in connection with a general system of sewage disposal for the city of Salem and the town of Peabody, for which, as you are aware, the State Board of Health is now making investigations.

It is understood, however, that no system of sewerage is at present contemplated by the town, and under the circumstances it becomes important to determine whether it is feasible to purify this sewage to such a degree that it may be discharged into the stream without causing offence. It could probably be done by conducting the sewage into large settling tanks, where the sludge would settle and the liquid could be pumped to a sand and gravel bed and be filtered, and the sludge be frequently removed from the tanks. The Board cannot with present information advise you definitely with regard to this method of disposal, but will assist you in making an investigation of it, if you desire.

**FAIRHAVEN.** The selectmen of Fairhaven applied to the Board on Dec. 16, 1895, for its advice relative to the best practicable method of disposing of the sewage of the village of Fairhaven, submitting a plan for its disposal by one outlet into tide-water at the end of the wharf. The Board replied to this application as follows:—

BOSTON, June 7, 1895.

The plan provides for a system of gravity pipe sewers for collecting the sewage at four points, at each of which Shone ejectors are to be placed, to force the sewage to the outlet above mentioned.

The Board, on May 5, 1891, in reply to a previous application, approved the outlet for the discharge of the sewage of certain public buildings and a small portion of the town, but regards it as an unsatisfactory outlet for a larger quantity of sewage which would be brought to this point by the present plan; and you are, therefore, advised to modify the plan so that the sewage will be carried farther out toward the channel, where it will not pollute the docks or shores. It seems probable that this may be done and a satisfactory outlet secured, without excessive cost, by laying a submerged sewer out from the shore at some point not farther north than the southerly end of Crow Island.

**FRAMINGHAM.** The sewer committee of Framingham applied to the Board Dec. 24, 1894, for its approval, under the provisions of

chapter 403 of the Acts of 1887, of the method of disposal of the water of the under-drain of the main sewers of that town. The Board replied to this application as follows : —

Boston, Feb. 20, 1895.

The Board has considered your application, dated Dec. 24, 1894, in which you ask for its approval of the disposal of the water of the under-drain beneath the Framingham sewers by pumping it to filter-beds located near the present pumping station, as shown on a plan submitted with the application.

A plan for the disposal of this water was presented to the Board Jan. 23, 1893, which provided for diverting it entirely from the water-shed of the Boston water supply by pumping it over the divide into Bannister Brook. Concerning that plan the Board advised that it was a permissible method of disposing of the water, but that filtration might be necessary if the character of the water should deteriorate.

The plan now proposed provides for the disposal of the water of the under-drain by filtration on land within the water-shed of the Boston water supply, and has the advantage of saving to this supply a quantity of water which under the former plan would be lost; but it has the disadvantage that the nitrates in the filtered water will have a slight tendency to promote the growth in Cochituate Lake of the organisms which impart to water disagreeable tastes and odors.

In view of all the circumstances, the Board is of the opinion that the disposal of the under-drain water by the proposed plan is not objectionable from a sanitary point of view, and is an appropriate method of disposing of this water.

Samples of earth sent in by you from three test pits dug in the proposed area have been examined, and the samples from two of them have been found to be of satisfactory quality, except near the surface, for filtration purposes, but samples from the remaining pit consisted of very fine material. In constructing the filter-beds care should be taken to locate them where the material is porous and suitable for filtration. The plan provides for the preparation of an area of about one acre, but it would be desirable to make provision for extending this area in the future if it should be found necessary.

SPRINGFIELD. The mayor of Springfield applied to the Board Aug. 23, 1895, for advice relative to the extension of certain sewers to the Connecticut River, and the construction of new sewers having their proposed outlets in the river. The Board replied to this application as follows : —

**Boston, Oct. 3, 1895.**

The State Board of Health received from you on Aug. 23, 1895, an application for its advice relative to the proposed extension to the river channel of the sewer outlets in Worthington and Union streets, which now discharge at the bank of the river, and the construction of a new sewer in Conhill street, accompanied by plans showing details of the proposed extensions and the results of float experiments made to determine the direction of currents in the river opposite the city.

The discharge of sewage at the bank of the river has caused a serious muling of the shores, so that at times of low water they are very offensive. The proposed extensions will carry the sewage away from the river bank well out into the stream, and the points of discharge indicated appear to be so located that the sewage will have passed the city and become well diluted before returning to the shores, and their adoption is recommended. It would, however, be well to avoid the up-turning of the discharge pipe at the end, and have a free outlet, with no depressed portion of the pipe in which solids from the sewage may be deposited.

**TWICKSBURY.** An application was received from the board of health of Twicksbury, April 9, 1895, for advice relative to the disposal of the sewage of a portion of that town into the Concord river. The Board replied as follows:—

**Boston, Oct. 3, 1895.**

The State Board of Health received from you on April 9, 1895, an application with reference to a partial system of sewerage in the portion of Twicksbury bordering on the Concord River, accompanied by a profile showing a proposed sewer in Whitehead and Warnock streets, ending in the Concord River, near the boundary between the town of Twicksbury and the city of Lowell.

The Board has caused an investigation of the proposed plan to be made, and has deemed it necessary, in view of the existing conditions, to take into consideration the whole subject of sewerage and sewage disposal for the rapidly growing portion of the town near to Lowell. Aside from the locality to be drained by the proposed sewer, there are other localities in a part of the town, containing a much larger population, which appear to be already in need of sewerage facilities, or, with a continued rapid increase in population, likely to need them in the near future.

While the discharge of sewage from the proposed sewer, under present conditions, into the Concord River, might not cause any serious harm, the board is of the opinion that no large amount of sewage can safely be disposed of in this way, owing to the conditions that prevail in the vicinity of the river below, where there are densely populated sections of the city of

Lowell in the immediate vicinity of the stream. It is also worthy of note that the city of Lowell has been compelled by the courts to discontinue the discharge of sewage into the Concord River, above the last dam.

In view of all the circumstances, the Board advises that a more extended investigation be made of the subject of sewerage and sewage disposal for this rapidly growing portion of the town of Tewksbury, both in order that sewers may be constructed in the beginning in accordance with some well-defined plan for the district as a whole, and in order that a suitable method of disposing of the sewage be adopted in the beginning.

It is suggested that, in connection with investigations of methods of disposing of the sewage of this portion of the town, there appear to be two feasible methods which are worthy of investigation, — one by disposal on filter-beds of sufficient area, as at Framingham, Marlborough and several places in the State, and the other by disposal in connection with the sewerage system of the city of Lowell.

The Board will advise you further in this matter when you have additional information to present.

**WEBSTER.** The sewer commissioners of Webster applied to the Board Oct. 15, 1895, for its advice relative to a proposed system of sewerage and sewage disposal for that town, having its outlet into French's River, at a point below the bridge of the Southbridge branch of the New England Railroad. The Board replied to this application as follows : —

Boston, Jan. 3, 1896.

From investigations made by the Board, through its engineers, it appears that French's River is already considerably polluted by manufacturing sewage. Below the proposed sewer outlet there are several millponds which afford a favorable opportunity for the solid portions of the sewage and manufacturing wastes to settle and become offensive. Near each of these millponds is a village, the inhabitants of which would necessarily be affected by the pollution of the river and the deposits of organic matter on the bottoms and sides of the ponds.

Under the circumstances, the Board does not advise the disposal of the sewage of Webster as proposed, by discharging it without treatment into French's River, but advises a further investigation of the subject of sewage disposal, with a view to purifying the sewage in such a manner that the effluent may subsequently be discharged into the river without danger of causing offence to the inhabitants of the villages on the river below.

A tract of land is referred to in the report of your engineer in connection with the disposal of the sewage by filtration or irrigation. The Board would advise a thorough investigation of the areas suitable for the dis-

al of sewage in the vicinity of the river below the proposed outfall, determine the location and extent of the areas available for sewage ation.

The Board will advise you further in this matter when you have additional information to present.

**STATE FARM AT BRIDGEWATER.** An application was received in the superintendent of the State Farm at Bridgewater for the advice of the Board relative to the disposal of the sewage of that institution. The Board replied as follows : —

Boston, Dec. 14, 1895.

The State Board of Health has carefully considered your application for advice as to the disposal of the sewage of the State Farm, and has caused examination of the territory in the vicinity of the farm to be made by engineers.

The present method of disposing of the sewage after leaving the buildings is to convey it to settling tanks just outside the northwesterly corner of the grounds of the institution, from which it is allowed to overflow and down the hill into a small brook, which is very badly polluted thereby, thence into the Taunton River.

While you have a large area of land upon which sewage might be used for irrigation, and some advantages to the crops be obtained thereby, the soil is not favorable to absorbing a large amount of the sewage, and would have to be applied with a good deal of care to prevent its becoming noxious.

North of the institution, beyond the brook and about a mile and a quarter from the buildings, you have some land which appears to be adapted to agriculture; and the Board would advise that you cause an examination to be made, to determine whether this area is available for the disposal of the sewage of the institution at a reasonable expense, and whether the area of available porous material is of sufficient extent to filter all of the sewage of the institution, and produce an effluent that may be discharged into the Taunton River without objection.

#### **POLLUTION OF INLAND WATERS.**

**THE BLACKSTONE RIVER.** An application was received Aug. 17, 1895, from the selectmen of Millbury, asking the advice of the Board "in reference to the pollution of the Blackstone River by sewage and by the effluent from the sewage precipitation works



4, averaged about 12,500,000 gallons per day, and that a portion of sewage at times of high flow in the brook escapes into the river without treatment.

The population of the city of Worcester has increased since 1886 about ty-nine per cent., and the total length of sewers has increased during t time about eighty-seven per cent., from which it would be reasonable conclude that the amount of sewage discharged by the sewers has ible. It appears from the report of the superintendent of sewers that, an average, about fifty per cent. of the organic matter is removed from sewage by treatment at the precipitation works; and, taking into consideration the fact that a portion of the sewage escapes into the river without treatment, it would be expected that the amount of organic matter discharged into the river in the sewage and effluent of the city of Worcester is great as in 1886.

As a means of determining the condition of the river from time to time, Board has continued its regular examination; and, in order to compare condition of the river in 1895 with that existing before the last reply made, the Board has caused a special examination of the river to be de by means of numerous chemical analyses of samples collected at ous points and at frequent intervals during the week ending Sept. 11, 1895, corresponding to an examination made in the week ending July 29, 1891. From the results of these investigations the Board finds that the dition of the river below the point of discharge of the effluent from the cipitation works and in the town of Millbury is practically the same as was at the time when the last reply was made.

The Worcester precipitation works have been conducted under the direction of skilled engineers and chemists, and the percentage of organic matter removed from the sewage treated at the works, even on the scale required, has doubtless been as great as it is practicable to attain by chemical precipitation alone. As the city grows and the amount of sewage increases, the amount of organic matter discharged into the river will also necessarily increase, unless a more complete purification of the sewage is de.

**LAKE QUINSIGAMOND.** The selectmen of Shrewsbury called the attention of the Board July 1, 1895, to the possible pollution of Lake Quinsigamond (which lies partly in Shrewsbury) by the sewage of the Worcester Lunatic Hospital. The Board replied to this communication as follows:—

Boston, Dec. 5, 1895.

The State Board of Health has considered your application with reference to the pollution of Lake Quinsigamond by the sewage from the

Worcester Lunatic Hospital, and has caused an examination of the premises to be made.

From present information the Board is not prepared to give an opinion in this matter, but will cause a further investigation to be made during the coming year, and will then inform you as to its conclusions.

LAKE CHAUNCY. The following communication was received from the selectmen of Northborough Sept. 17, 1895:—

NORTHBOROUGH, MASS., Sept. 17, 1895.

GENTLEMEN :— For a number of months the sewage of the Westborough Insane Hospital has been discharged directly and without treatment into Lake Chauncy, one of the great ponds of the State, and within the limits of this town.

We respectfully ask you to examine the premises, and if, in your opinion, the conditions are prejudicial to health or comfort, to take such action as may be necessary.

Respectfully,

(Signed)

CYRUS H. MENTZER,

EDWIN S. COREY,

JAMES S. LEARNED,

*Selectmen of Northborough.*

In consequence of this letter the following communication was sent to the trustees of the Westborough Lunatic Hospital, and a copy of the same was also sent to the selectmen of Northborough :—

Boston, Dec. 5, 1895.

Information has been received from the selectmen of Northborough that for a number of months the sewage of the Westborough Insane Hospital has been discharged directly and without treatment into Little Chauncy Pond. The investigations made by the Board, through one of its engineers, show that such is the case, and that there is strong evidence that this condition has existed for a considerable time.

This method of disposal of the sewage causes the serious pollution of Little Chauncy Pond and the stream flowing from it through Northborough into the Assabet River, and is a menace to the public health. It is not, in any sense, a proper method of disposing of the sewage from this institution, and should not be allowed to continue.

In 1887 the trustees of the hospital requested the Board to examine the sewerage system of the hospital and recommend a proper method of disposal. After careful examination of the premises by the engineer of the

ard, a reply was made to the effect that the most suitable method of disposal was upon land situated on the opposite side of the brook leading from auney Pond to Little Chauncy Pond.

A few months later a general plan for a system of subsurface disposal was presented by you through your engineer, which provided for disposal on a tract of land upon the side hill north-westerly from the hospital. On inspection of the area upon which it was proposed to dispose of the sewage, it did not appear to the Board that it was adapted to the purpose; but after giving a hearing, at which your engineer explained the nature of the ground on which it was proposed to dispose of the sewage, and the general features of the plan, it appeared from his account that the material, shown by the trial pits, proved to be so much better adapted to the filtration of sewage than inspection of its surface promised, that the committee on water supply and sewerage of the Board saw no reason to doubt that the sewage of the hospital could be disposed of upon it without risk to the health of the inmates or the public. Your engineer declined to explain details of the method of distribution, and the Board expressed no opinion upon this subject.

Since it now appears that the sewage is not purified by this method, and is very improbable that with such soil as that of which the field is composed the sewage could be properly disposed of under the most favorable circumstances by subsurface irrigation, the Board advises that you convey the sewage across the brook, and dispose of it by filtration upon the tract of land which investigation has shown to be available, in general accordance with the advice of the Board contained in the communication addressed to you May 9, 1887, previous to the adoption of the present system.

The Board will, on application, advise you further as to the details of a plan for the satisfactory disposal of the sewage, if you desire it.

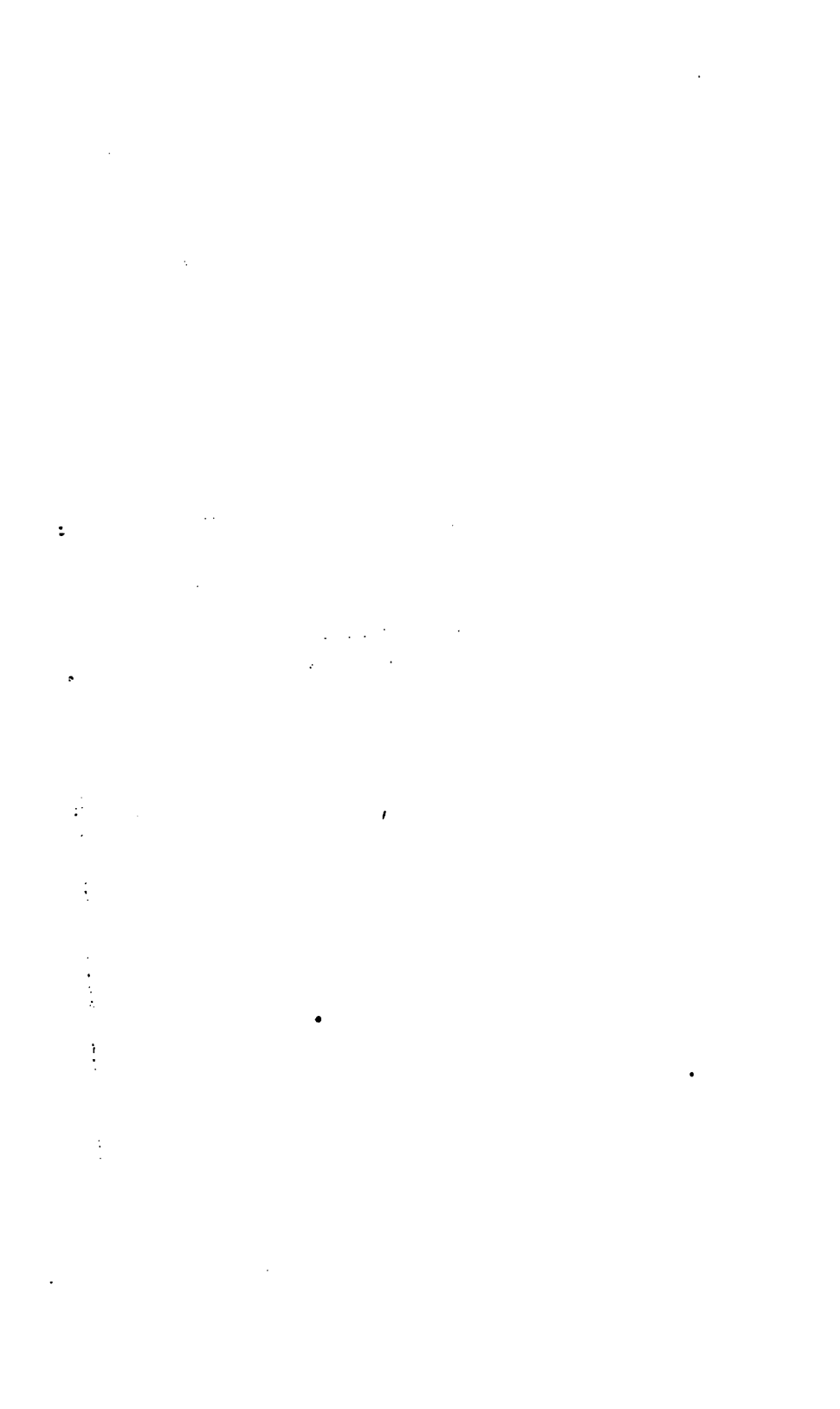
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## MINATION OF WATER SUPPLIES.

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# EXAMINATION OF WATER SUPPLIES.

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## EXPLANATORY NOTE.

The systematic examination of the water supplies of the State was begun June 1, 7, and has been continued up to the present time. The results of the investigations made during the first two years were published in a special report of the Board upon the Examination of Water Supplies (1890), and of those made during succeeding years in the annual reports of the Board beginning with the 1890 (Twenty-second Annual) report.

The special report contains a description of each of the water supplies in the State existing at the date of that report, and the annual reports contain descriptions of new works and changes in existing works.

In all of these reports an alphabetical arrangement by towns has been adopted. Records of water supply are tabulated under the name of the town supplied, other records under the name of the town in which they are situated. The analyses of waters from the larger rivers not used as sources of water supply are given in a subsequent tabulation, headed "Examination of Rivers."

The method of making the chemical examinations remains unchanged, and the results are presented in the tables of this report in the same form as in the last one. The samples of water are usually received at the laboratory from twenty-four to thirty-eight hours after collection. All surface water and such samples of ground water as contain suspended matter are filtered through filter-paper before determining the color, the residue on evaporation and the albuminoid ammonia in solution. Ground waters which are perfectly clear and colorless when drawn from the well and become turbid and colored on standing, in consequence of the oxidation of the iron which they contain. In these waters the residue on evaporation is determined without filtration, since this iron is an essential and not an accidental ingredient in the water. In the changes which accompany the oxidation of the iron in waters of this character, they become first cloudy (well described by the word "opalescent") and finally deposit a precipitate of oxide of iron. In the cloudy condition waters have a distinct color, which while it does not have the same significance as in the case of surface waters, and is only a passing phenomenon, is, nevertheless, of great value as showing a color which the water may assume while the oxidation of the iron is in progress. When the iron is all oxidized and precipitated the water may become colorless again. Explanatory notes will be given for waters of this kind in connection with the tables of analyses.

The color of water is expressed by numbers which increase with the amount of

The standard used is nesslerized ammonia, as described on page 531 of the Special Report upon the Examination of Water Supplies, 1890, and on page 329 of the Annual Report for 1892. Boston water, as drawn from a tap at the Institute of Technology, had an average color in 1895 of 0.72. Other water supplies in the State have had an average color of from 0 to 1.30.

In cases where examinations of a source have been made with considerable regularity for several years, the averages of the chemical analyses of each year are given.

There was no change in the method employed in the microscopical examination of water between Nov. 6, 1890, and Dec. 1, 1895. The method employed between those dates is fully described in the Twenty-third Annual Report of the Board for the year 1891 (pages 395-421). Before Nov. 6, 1890, the methods employed were less perfect, so that a smaller proportion of the total number of organisms present in the water was separated from it and observed under the microscope; and, before drawing conclusions from a comparison of the microscopical examinations of waters made before and after this date, the explanatory note on page 70 of the Twenty-second Annual Report for 1890 should be read.

Since Dec. 1, 1895, the method for the microscopical analysis of water has been considerably improved by discarding the ordinary glass funnels previously employed and substituting funnels which have been constructed with stems of equal calibre, to give equal rates of filtration, and with steeper sides, so that those organisms which are of a gelatinous character will be less liable to adhere to the sides of the funnel. By the use of these funnels variations in the numbers of organisms found, which may be caused by dissimilar slopes of the sides of the funnels and unequal rates of filtration, are avoided.

To indicate the amount of the so-called *Zoöglæa* observed, the number of individual masses is not counted, but an area equal to 2,500 square microns, or .0025 square millimeters, has been adopted as an arbitrary unit.

In publishing the results of the microscopical examinations the same system is followed as last year. The plants observed are classified in four groups, viz.: Diatomaceæ, Cyanophyceæ, Algæ and Fungi. The animals observed are grouped as Rhizopoda, Infusoria, Vermes and Crustacea.

The names of the different genera in each group are given with the numbers of each per cubic centimeter, except that, to avoid making the tables excessively long, they are omitted when present only in very small numbers. It is not feasible to make with regard to omissions a single rule which will apply to all cases, because it is desirable to include smaller numbers of animals than of plants, and of the larger animals than of animals generally. Moreover there are exceptional cases in which it is desirable to indicate the presence of even very small numbers of the more important plants or animals. Two general rules, however, have been adopted in printing the results, viz. :—

1. All genera of plants are included in which the total number observed in twelve months amounts to 6 or more per cubic centimeter, or, in other words, averages as much as 0.5 per month.

2. All genera of animals are included in which the total number observed in twelve months amounts to 1.5 or more per cubic centimeter.

The larger microscopic animals, such as some of the Crustacea, are included, even when present only in very small numbers.

Fractions are generally omitted from the table, the nearest whole number of organisms per cubic centimeter being given. Where the total number of organisms observed is 0.5 or less, the fact that the organism was present is usually indicated by the abbreviation "pr.," but in the case of the larger organisms very small fractions are given.

## EXAMINATION OF WATER SUPPLIES.

### WATER SUPPLY OF ABINGTON AND ROCKLAND.

*Chemical Examination of Water from Big Sandy Pond, Pembroke.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. |           |
|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|----------------|-----------|----------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                |           | Nitrates.      | Nitrites. | Oxygen Consumed. | Hardness. |
|                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended |           |                |           |                  |           |
| 1893.<br>Feb. 10    | V. slight.  | Slight.   | .20    | 3.15                            | 0.90                 | .0036    | .0182       | .0182      | .0020          | .70       | .0000          | .0000     | .2800            | 1.1       |
| Mar. 11             | V. slight.  | Slight.   | .10    | 3.05                            | 0.70                 | .0004    | .0146       | .0126      | .0020          | .65       | .0050          | .0000     | .2310            | 0.6       |
| Apr. 11             | Distinct.   | Slight.   | .10    | 2.70                            | 1.10                 | .0000    | .0168       | .0184      | .0004          | .64       | .0000          | .0000     | .2926            | 0.5       |
| .....               | .....       | .....     | .13    | 2.97                            | 0.90                 | .0013    | .0165       | .0151      | .0014          | .66       | .0017          | .0000     | .2679            | 0.7       |

### Averages by Years.

|       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| 1887* | - | - | .20 | 3.45 | 0.94 | .0008 | .0150 | -     | -     | .58 | .0056 | -     | -     | -   |
| 1888† | - | - | .10 | 3.23 | 0.82 | .0006 | .0164 | -     | -     | .55 | .0073 | .0001 | -     | -   |
| 1892‡ | - | - | .10 | 4.30 | -    | .0000 | .0200 | .0150 | .0050 | .59 | .0090 | .0000 | -     | 0.5 |
| 1893  | - | - | .07 | 3.19 | 1.19 | .0010 | .0146 | .0122 | .0024 | .63 | .0012 | .0000 | .2130 | 0.5 |
| 1894§ | - | - | .04 | 2.75 | 1.00 | .0003 | .0131 | .0109 | .0022 | .62 | .0050 | .0000 | .1730 | 0.2 |
| 1895  | - | - | .13 | 2.97 | 0.90 | .0013 | .0165 | .0151 | .0014 | .66 | .0017 | .0000 | .2679 | 0.7 |

\* June to October, six samples.

† January to April, five samples.

‡ March.

§ March and April.

|| February, March and April.

urns to analyses of 1895: Odor of the first sample distinctly vegetable, becoming unpleasant on g; of the second, faintly aromatic, becoming distinctly vegetable and unpleasant on heating; of ird, very faint or none, becoming faintly vegetable on heating. — The samples were collected faucet at the pumping station.

### Microscopical Examination.

e total number of organisms per cubic centimeter found in each sample was as follows: No. 4; No. 12061, 88; No. 14123, 717, consisting chiefly of *Dinobryon* and *Synedra*.



## ACTON.

## ACTON.

*Chemical Examination of Water from Tubular Test Wells in Acton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |                |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------------|----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.        | Sediment.      | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 14797   | 1895. Aug. 10       | Slight, clayey.   | Heavy, sandy.  | .02    | 5.80                    | .0004    | .0004       | .22       | .0100       | .0000     | .0624            | 2.6       | .0050 |
| 14798   | Aug. 10             | Distinct, clayey. | Heavy, sandy.  | .04    | 5.50                    | .0002    | .0000       | .22       | .0040       | .0000     | .0783            | 2.6       | .0100 |
| 15166   | Sept. 13            | Decided, clayey.  | Cons., earthy. | .04    | 6.70                    | .0000    | .0010       | .22       | .0030       | .0000     | .0406            | 2.6       | .0370 |

Odor, none. — The samples were collected from tubular test wells in Acton, which were located approximately as follows: No. 14797, 250 feet east of the town line between Acton and Boxborough and about 350 feet north of Massachusetts Avenue. No. 14798, about 340 feet east of the same boundary line and 500 feet north of Massachusetts Avenue. No. 15166, about 35 feet east of the boundary line and 280 feet north of Massachusetts Avenue. The analyses were made in connection with an investigation for a water supply for the town of Acton.

*Microscopical Examination.*

No organisms.

*Chemical Examination of Water from Fort Pond, Littleton, and Magog Brook and Magog Pond, Acton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|--------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                         | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 15784   | 1895.<br>Dec. 20    | V. slight.  | V. slight. | .30    | 3.10                           | 1.20                 | .0046    | .0170       | .0136      | .0034           | .23       | .0100          | .0001     | .3311            | 6.5       |
| 15785   | Dec. 20             | V. slight.  | Cons.      | .57    | 3.30                           | 1.55                 | .0004    | .0170       | .0126      | .0044           | .22       | .0100          | .0000     | .5390            | 6.5       |
| 15786   | Dec. 20             | V. slight.  | Slight.    | .10    | 2.45                           | 1.30                 | .0028    | .0332       | .0296      | .0036           | .30       | .0000          | .0000     | .2141            | 6.3       |

Odor, none; on heating, the first two samples had a faintly vegetable odor. — The samples were collected as follows: No. 15784, from Fort Pond, about 30 feet from the shore at the southerly end; No. 15785, from Magog Brook, about 50 feet above the road leading from Acton Centre to North Acton and about one mile below Magog Pond; No. 15786, from Magog Pond, near the road at the easterly end.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 15784, 123; No. 15785, 43; No. 15786, 41.

ADAMS.

## WATER SUPPLY OF ADAMS FIRE DISTRICT, ADAMS.

The advice of the State Board of Health to the Adams Fire District with reference to an additional supply of water may be found pages 10-13 of this volume.

The present sources of supply are Bassett and Dry brooks, one of which there is a small reservoir. An auxiliary supply is obtained from a well of the Renfrew Manufacturing Company in the village, and during the drier portion of 1895 a small additional quantity of water is said to have been pumped from tubular wells at the Zylonite Works in the northerly portion of the village.

The results of analyses of samples of water from these sources and from other sources investigated with reference to an additional water supply for the Fire District are given in the following tables.

*Chemical Examination of Water from Bassett Brook, Adams.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.               |             |           |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| Apr. 17             | None.       | Slight.   | .05    | 2.70                            | 1.00                 | .0000    | .0048       | .0042      | .0006           | .07       | .0600          | .0000     | .1698            | 1.1       |
| Sept. 8             | None.       | V slight. | .08    | 6.40                            | 0.00                 | .0000    | .0014       | -          | -               | .10       | .0110          | -         | -                | 3.2       |
| Sept. 11            | Slight.     | Slight.   | .07    | 7.20                            | 0.00                 | .0000    | .0042       | .0038      | .0004           | .12       | .0130          | .0000     | .1092            | 5.0       |

Odor, none. — The first sample was collected from a tap in the town and represents water from Bassett Brook; the second, from Bassett Brook just above the reservoir; the third, from the reservoir.

*Microscopical Examination.*

No. 15083 was not examined. An insignificant number of organisms was found in the other samples.

**ADAMS.***Chemical Examination of Water from Dry Brook in Adams and Cheshire.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 14180   | 1895.<br>Apr. 17    | Slight.     | Cons.,<br>earthy. | .35    | 3.40                            | 1.70                 | .0004    | .0100       | .0084      | .0016           | .06       | .0050          | .0000     | .5214            | 1.6       |
| 14302   | May 14              | V. slight.  | Slight.           | .65    | 4.55                            | 2.00                 | .0008    | .0164       | .0150      | .0014           | .04       | .0040          | .0000     | .7685            | 2.2       |
| 14303   | May 14              | V. slight.  | Slight.           | .35    | 6.30                            | 1.90                 | .0004    | .0116       | .0088      | .0028           | .06       | .0020          | .0000     | .4858            | 3.6       |
| 15085   | Sept. 7             | None.       | V. slight.        | .10    | 11.50                           | 0.30                 | .0000    | .0068       | -          | -               | .17       | .0000          | -         | -                | 9.4       |
| 15159   | Sept. 11            | Slight.     | Slight.           | .08    | 11.50                           | 0.40                 | .0000    | .0086       | .0058      | .0028           | .10       | .0050          | .0000     | .1872            | 8.4       |

Odor, very faint or none. — No. 14180 was collected from the brook about 2 miles above the reservoir; No. 14302 just below the road crossing above the sand mill and 2.5 miles above the reservoir; Nos. 14303 and 15159 from the reservoir; No. 15085 from the brook just above the reservoir.

*Microscopical Examination.*

No. 15085 was not examined. An insignificant number of organisms was found in each of the other samples.

*Chemical Examination of Water from the Well of the Renfrew Manufacturing Company, Adams.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         |                     |             |            |        |                        |          |             |           |             |           |                  |           |       |
| 14216   | 1895.<br>Apr. 29    | None.       | V. slight. | .00    | 14.70                  | .0000    | .0006       | .18       | .1000       | .0000     | .0038            | 12.3      | .0000 |
| 15086   | Sept. 7             | None.       | None.      | .00    | 15.80                  | .0000    | .0000       | .13       | .0500       | -         | -                | 12.6      | .0070 |

Odor, none. — The samples were collected from a faucet at the pumping station.

*Microscopical Examination.*

No. 14216. No organisms.

No. 15086. Not examined.

ADAMS.

*nical Examination of Water from a Tubular Well at the Zylonite Works in the Northerly Portion of the Village of Adams.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 1895.<br>Apr. 17    | None. *     | None.     | .00    | 13.80                   | .0000    | .0000*      | .10       | .0500       | .0000     | .0197            | 11.9      | .0020 |

odor, none. — The sample was collected from one of the wells which was flowing at the time.

*Microscopical Examination.*

fo organisms.

*Chemical Examination of Water from South Brook in Cheshire.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------------------|-------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment.         | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|                     |             |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.<br>Apr. 17    | V. slight.  | Cons.,<br>earthy. | .25    | 3.60                            | 1.65                 | .0012    | .0100       | .0090      | .0010           | .07       | .0300          | .0000     | .4147            | 1.6       |
| Sept. 7             | None.       | V. slight.        | .18    | 4.70                            | 0.50                 | .0004    | .0048       | -          | -               | .13       | .0110          | -         | -                | 3.2       |

odor, very faintly vegetable. — The first sample was collected from the brook below the sand mill, t 0.3 of a mile from the point where the brook joins the Hoosac River; the second, from the brook s the sand mill, about a mile from the point where the brook joins the river.

*Microscopical Examination.*

fo. 14179. An insignificant number of organisms was found in this sample.  
fo. 15084 was not examined.

## ADAMS.

*Chemical Examination of Water from Tophet Brook in Adams.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 14188   | 1895.<br>Apr. 17    | -           | -          | .27    | -                               | -                    | -        | -           | -          | .10             | -         | -              | -         | 1.4              |           |
| 15071   | Sept. 7             | None.       | V. slight. | .03    | 8.70                            | 0.00                 | .0000    | .0046       | .0034      | .0012           | .15       | .0020          | .0002     | .1131            | 7.6       |

Odor of the first sample, not determined; of the second, very faintly vegetable, becoming somewhat stronger and mouldy on heating. — The samples were collected from the brook, at a road crossing about 1.25 miles above its mouth.

*Microscopical Examination.*

No. 14188. Not examined.

No. 15071. An insignificant number of organisms was found in this sample.

*Chemical Examination of Water from the Hoosac River and from Fisk and Anthony Brooks in Adams.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |           |
| 14304   | 1895.<br>May 14     | Decided.    | Slight.   | .20    | 6.33                    | 1.45              | .0000    | .0150       | .0110      | .0040           | .08       | .0050       | .0000     | .2686            | 5.1       |
| 14321   | June 20             | Distinct.   | Cons.     | .23    | 8.60                    | 1.73              | .0014    | .0220       | .0184      | .0036           | .08       | .0050       | .0001     | .4019            | 6.7       |
| 14336   | May 29              | None.       | Slight.   | .07    | 9.50                    | 1.80              | .0000    | .0038       | .0032      | .0006           | .08       | .0230       | .0000     | .1026            | 6.7       |
| 14337   | May 29              | None.       | Slight.   | .12    | 4.30                    | 1.60              | .0002    | .0068       | .0054      | .0014           | .10       | .0050       | .0000     | .1938            | 2.6       |

Odor of the first two samples, distinct; of the others, none. — The first two samples were collected from the Hoosac River at a railroad crossing just above Cheeshire Harbor; the third from Fisk or Dean Brook just below Peck's Falls; the last from Anthony Brook just below the road from Savoy Centre to Adams.

*Microscopical Examination.*

An insignificant number of organisms was found in each of these samples.

ADAMS.

*Chemical Examination of Water from Various Ground Water Sources in the Vicinity of Adams.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |                   |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------------|-------------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.        | Sediment.         | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1895.</b>        |                   |                   |        |                         |          |             |           |             |           |                  |           |       |
| 4305    | May 14              | Decided, clayey.  | Cons., earthy.    | .20    | 9.05                    | .0570    | .0220       | .10       | .0210       | .0000     | .3041            | 6.0       | .0700 |
| 4388    | May 29              | None.             | Cons.             | .00    | 12.30                   | .0000    | .0010       | .12       | .0600       | .0000     | .0380            | 10.0      | .0080 |
| 4389    | May 29              | None.             | Cons., floccul't. | .00    | 14.70                   | .0016    | .0038       | .09       | .0600       | .0000     | .0228            | 13.3      | .0000 |
| 4522    | June 20             | Distinct, clayey. | Cons., earthy.    | .00    | 12.00                   | .0004    | .0002       | .08       | .0200       | .0000     | .0293            | 10.3      | .0000 |
| 4523    | June 20             | None.             | V. slight.        | .00    | 12.10                   | .0002    | .0002       | .12       | .0300       | .0000     | .0000            | 10.6      | .0080 |
| 4584    | June 29             | Decided, clayey.  | Cons., sandy.     | .00    | 17.70                   | .0000    | .0000       | .04       | .0930       | .0000     | .0174            | 14.8      | .0100 |
| 5072    | Sept. 7             | None.             | Slight, white.    | .02    | 13.00                   | .0000    | .0002       | .12       | .0400       | .0000     | .0312            | 11.0      | .0140 |

Odor of 14390, faintly vegetable and disagreeable, disappearing on heating; of the other samples, none.—The samples were collected as follows: No. 14305 from a test pit 30 feet from the Hoosac River on the west side of the Boston & Albany Railroad, 2,000 feet south of the railroad bridge over the Hoosac River, just above Cheshire Harbor; No. 14384, from the west spring of the Brown Paper Company; No. 14390, from Follett's Spring, opposite Follett's lime works, in the northerly part of Adams; the remaining samples, from test wells in the valley of the Hoosac River, about half a mile above Cheshire Harbor.

*Microscopical Examination.*

No. 14305. Miscellaneous, *Zoëglæa*, 4,600.

No. 14388. Diatomaceæ, *Synedra*, 1.

No. 14390. Diatomaceæ, *Diatoma*, 1; *Navicula*, 4; *Pinnularia*, 1; *Synedra*, 80. Total, 86.

No organisms were found in the remaining samples.

**WATER SUPPLY OF AMESBURY.—POWOW HILL WATER COMPANY.**

The advice of the State Board of Health to the Powow Hill Water Company relative to taking an additional supply of water from the pond near Main Street in that town may be found on pages 13 and 14 of this volume. Analyses of samples of water collected from the present and other sources, in connection with the investigation for an additional supply, are given in the following tables.

**AMESBURY.***Chemical Examination of Water from Tubular Wells supplying Open Basins near Main Street.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|----------------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment.      | Color. |                         | Free.    | Albu- minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 14242   | 1895.<br>May 1      | Slight.          | Slight.        | .03    | 9.30                    | .0004    | .0020         | .50       | .0550       | .0000     | .0000            | 3.9       | .0100 |
| 14849   | Aug. 17             | Distinct, milky. | Slight, green. | .12    | 10.00                   | .0004    | .0024         | .60       | .0450       | .0001     | .1326            | 3.8       | .0300 |

Odor of the first sample, faintly unpleasant, disappearing on heating; of the second sample, none.  
 — The samples were collected at the pumping station on Main Street.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows:  
 No. 14242, 164; No. 14849, 363.

*Chemical Examination of Water from Thirty-six Tubular Wells near Market Street, and from an Open Distributing Reservoir supplied from these Wells.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.    |               |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|----------------|---------------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.     | Sediment.     | Color. |                         | Free.    | Albu- minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 15167   | 1895.<br>Sept. 14   | Slight, milky. | None.         | .02    | 20.70                   | .0028    | .0008         | 1.02      | .0030       | .0000     | .0140            | 10.9      | .0130 |
| 14243   | May 4               | Slight.        | Cons., white. | .04    | 18.90                   | .0000    | .0182         | 1.16      | .0030       | .0000     | .2772            | 8.0       | .0010 |

Odor of the first sample, none; of the last, distinctly unpleasant. — The first sample was collected at the pumping station on Market Street, and the last from a faucet connected with the upper reservoir and the Market Street station.

*Microscopical Examination.*

No. 15167, Fungi, *Oreothartia*, 1. Miscellaneous, *Zoëglan*, 7. Total, 8.  
 No. 14243, Diatomaceæ, *Asterionella*, 32; *Synedra*, 16,000. Vermes, *Anurea*, 24; *Rotatorian* ova, 1. Total, 16,057.

## AMESBURY.

*Chemical Examination of Water from a Tubular Test Well in Amesbury.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 13043   | 1894.<br>Sept. 28   | None.       | None.     | .07    | 8.00                    | .0030    | .0002       | .32       | .0060       | .0000     | .0280            | 3.1       | .0030 |
| 14241   | 1895.<br>May 1      | None.       | None.     | .00    | 7.20                    | .0000    | .0000       | .33       | .0030       | .0000     | .0000            | 3.0       | .0090 |

Odor, none. — The samples were collected from a tubular test well about 2,000 feet south of the pumping station on Main Street.

*Microscopical Examination.*

No organisms.

*Chemical Examination of Water from Kimball's Pond, Amesbury.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 4240    | 1895.<br>May 3      | Slight.     | Cons.     | .58    | 4.05                    | 1.75              | .0014    | .0172       | .0162      | .0010      | .38       | .0000       | .0000     | .6399            | 1.3       |

Odor, distinctly vegetable and sweetish, becoming stronger on heating. — This pond is not used as a source of public water supply.

*Microscopical Examination.*

Diatomaceæ, *Asterionella*, 24; *Cyclotella*, 9; *Cymbella*, 2; *Epithemia*, 1; *Fragilaria*, 13; *Melosira*, 10; *Navicula*, 13; *Pinnularia*, 1; *Synedra*, 153; *Tabellaria*, 10. Algæ, *Closterium*, 1; *Desmidiium*, 1; *rotococcus*, 3. Fungi, *Crenothrix*, 4. Rhizopoda, *Actinophrys*, 1. Infusoria, *Dinobryon*, 27; *Dinobryon* *acea*, 192; *Synura*, 3. Vermes, *Rotifer*, 2. Miscellaneous, *Zoëglia*, 48. Total, 698.



## ANDOVER.

## WATER SUPPLY OF ANDOVER.

*Chemical Examination of Water from Haggell's Pond, Andover.*

[Parts per 100,000]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|-----------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                 |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                 |           |
| 13797   | 1895.<br>Feb. 11    | V. slight.  | V. slight. | .15    | 3.30                    | 0.90              | .0018    | .0146       | .0136      | .0010      | .35       | .0030       | .0000     | .2920           | 1.4       |
| 13965   | Mar. 12             | None.       | V. slight. | .12    | 3.40                    | 1.20              | .0026    | .0142       | .0128      | .0014      | .44       | .0050       | .0000     | .2941           | 1.6       |
| 14103   | Apr. 8              | V. slight.  | V. slight. | .17    | 3.95                    | 1.45              | .0020    | .0160       | .0136      | .0024      | .38       | .0040       | .0000     | .3234           | 1.7       |
| Av..    | .....               | .....       | .....      | .15    | 3.55                    | 1.18              | .0021    | .0149       | .0133      | .0016      | .39       | .0040       | .0000     | .3032           | 1.6       |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1889* | - | - | .10 | 5.85 | 2.70 | .0004 | .0198 | .0170 | .0028 | .29 | .0040 | .0001 | -     | 1.1 |
| - | 1891† | - | - | .08 | 3.35 | 1.70 | .0004 | .0136 | .0080 | .0056 | .33 | .0030 | .0000 | -     | 1.3 |
| - | 1892  | - | - | .06 | 3.20 | 1.02 | .0003 | .0175 | .0147 | .0028 | .34 | .0051 | .0000 | -     | 1.3 |
| - | 1893  | - | - | .09 | 3.30 | 1.30 | .0013 | .0151 | .0124 | .0027 | .34 | .0020 | .0000 | .2762 | 1.2 |
| - | 1894‡ | - | - | .09 | 3.34 | 1.18 | .0009 | .0122 | .0105 | .0017 | .34 | .0020 | .0000 | .2915 | 1.3 |
| - | 1895§ | - | - | .15 | 3.55 | 1.18 | .0021 | .0149 | .0133 | .0016 | .39 | .0040 | .0000 | .3032 | 1.6 |

\* July.

† November.

‡ January to April.

§ February, March and April.

NOTE to analyses of 1895: Odor, faintly vegetable. — The samples were collected from a faucet at the pumping station.

*Microscopical Examination.*

The average number of organisms per cubic centimeter found in these samples was 96, consisting chiefly of *Synedra* and *Dinobryon*.

## WATER SUPPLY OF ARLINGTON.

Works for the supply of the higher portions of the town were completed in the early part of 1895. The supply is drawn from twenty-five 2½-inch tubular wells located at the edge of the Great Meadows, near the Boston & Maine Railroad, opposite the East Lexington station. The wells have an average depth of about 35 feet. Water is forced from the wells to a covered iron tank, 40 feet in diameter and 60 feet high, situated on Arlington Heights. The capacity of this tank is 565,000 gallons.

ARLINGTON.

The advice of the State Board of Health to the town of Arlington, with reference to this source of water supply, may be found on pages 7 and 8 of the annual report for 1894, and analyses of samples of water collected during the investigations for an additional supply may be found in the annual reports of the Board for 1892 and 1893.

*Chemical Examination of Water from Tubular Wells at East Lexington.*

[Parts per 100,000.]

| No. of Sample. | Date of Collection. | APPEARANCE.       |               |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|----------------|---------------------|-------------------|---------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|                |                     | Turbidity.        | Sediment.     | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|                |                     |                   |               |        |                         |          |             |           |             |           |                  |           |       |
| 43             | 1895.<br>Apr. 15    | Slight, milky.    | V. slight.    | .20    | 9.00                    | .0094    | .0090       | .52       | .0080       | .0000     | .1422            | 5.4       | .0870 |
| 92             | Aug. 23             | Decided, rusty.   | Cons., rusty. | .23    | 11.00                   | .0084    | .0056       | .52       | .0000       | .0002     | .1872            | 5.4       | .1600 |
| 90             | Oct. 18             | Distinct, milky.  | Cons., rusty. | .18    | 10.30                   | .0114    | .0086       | .54       | .0070       | .0000     | .2356            | 5.9       | .0800 |
| 73             | Dec. 4              | V. slight, milky. | None.         | .08    | 9.30                    | .0094    | .0066       | .50       | .0030       | .0000     | .1732            | 5.1       | .0560 |
|                |                     |                   |               |        |                         |          |             |           |             |           |                  |           |       |
|                | .....               | .....             | .....         | .17    | 9.90                    | .0097    | .0075       | .52       | .0045       | .0001     | .1846            | 5.5       | .0958 |

Odor of the first and last samples, none; of the second, decidedly disagreeable; of the third, distly vegetable and sweetish. — The samples were collected from a faucet at the pumping station.

*Microscopical Examination.*

No. 14143. Fungi, *Oreothrix*, 9. Miscellaneous, *Zoëglæa*, 40. Total, 49.

No. 14902. Miscellaneous, *Zoëglæa*, 238.

No. 15400. Fungi, *Oreothrix*, 3,000.

No. 15678. Fungi, *Oreothrix*, 1,252.

*Chemical Examination of Water from the Storage Reservoir of the Arlington Water Works.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE.        |                  |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------------------|--------------------|------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                     | Turbidity.         | Sediment.        | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|                     |                    |                  |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.<br>Aug. 30    | Decided,<br>green. | Cons.,<br>green. | .65    | 7.90                            | 4.70                 | .0000    | .0822       | .0382      | .0440           | .69       | .0030          | .0002     | .7931            | 2.5       |

Odor, decidedly vegetable, grassy and mouldy. — The sample was collected from the reservoir.

*Microscopical Examination.*

Dyanophyceæ, *Anabæna*, 1,400; *Clathrocysts*, 950; *Calosphaerium*, 250. Algeæ, *Pediastrum*, 50; *edemus*, 50. Infusoria, *Monas*, 50. Total, 2,750.

## ASHBURNHAM.

*pical Examination of Water from Upper Naukeag Pond, Ashburnham.*

[Number of organisms per cubic centimeter.]

|                         | 1895. |        |       |       |
|-------------------------|-------|--------|-------|-------|
|                         | Feb.  | April. | July. | Aug.  |
| amination, . . . . .    | 15    | 10     | 24    | 13    |
| sample, . . . . .       | 13813 | 14122  | 14681 | 14801 |
| PLANTS.                 |       |        |       |       |
| ices, . . . . .         | 0     | 4      | 13    | 62    |
| onella, . . . . .       | 0     | 3      | 7     | 0     |
| ella, . . . . .         | 0     | 1      | 2     | 6     |
| ra, . . . . .           | 0     | pr.    | 3     | 2     |
| aria, . . . . .         | 0     | 0      | 1     | 64    |
| hyces, . . . . .        | 0     | 0      | 50    | 40    |
| nopedia, . . . . .      | 0     | 0      | 48    | 12    |
| ystia, . . . . .        | 0     | 0      | 2     | 28    |
| . . . . .               | 0     | 0      | 44    | 282   |
| occus, . . . . .        | 0     | 0      | 40    | 276   |
| dium, . . . . .         | 0     | 0      | 4     | 4     |
| strum, . . . . .        | 0     | 0      | 0     | 2     |
| ANIMALS.                |       |        |       |       |
| la, . . . . .           | 0     | 5      | 86    | 3     |
| ryon, . . . . .         | 0     | 0      | 86    | 0     |
| ryon cases, . . . . .   | 0     | 4      | 0     | 3     |
| nium, . . . . .         | 0     | 1      | 0     | 0     |
| ces, Cyclops, . . . . . | .01   | 0      | .02   | 0     |
| . . . . .               | 0     | 9      | 193   | 387   |

## ATHOL.

## WATER SUPPLY OF ATHOL.—ATHOL WATER COMPANY.

*Chemical Examination of Water from the Large Reservoir in Phillipston.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.     |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-----------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.      | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                 |                |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.   |                     |                 |                |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 13025   | Jan. 8              | Distinct.       | Slight.        | 0.90   | 4.70                    | 2.10              | .0034    | .0228       | .0208      | .0020      | .17       | .0070       | .0000     | .8580            | 1.4       |
| 13803   | Feb. 12             | Slight.         | Slight.        | 1.10   | 4.85                    | 2.10              | .0002    | .0234       | .0190      | .0044      | .17       | .0070       | .0000     | .9280            | 1.3       |
| 13954   | Mar. 11             | Distinct.       | Slight.        | 0.58   | 3.50                    | 1.40              | .0006    | .0276       | .0182      | .0114      | .15       | .0100       | .0000     | .6329            | 0.6       |
| 14265   | May 8               | Slight.         | Cons.          | 0.63   | 2.90                    | 1.60              | .0006    | .0150       | .0114      | .0036      | .11       | .0000       | .0000     | .6044            | 0.8       |
| 14639   | July 15             | Decided.        | Cons.          | 0.30   | 3.00                    | 1.00              | .0014    | .0298       | .0124      | .0174      | .13       | .0130       | .0000     | .3432            | 1.2       |
| 15213   | Sept. 18            | Decided, green. | Slight, green. | 0.63   | 4.25                    | 1.65              | .0006    | .1138       | .0284      | .0854      | .16       | .0070       | .0000     | .4797            | 0.6       |
| 15587   | Nov. 20             | Distinct.       | Slight.        | 0.33   | 4.80                    | 1.60              | .0042    | .0222       | .6138      | .0086      | .22       | .0330       | .0000     | .4524            | 1.4       |
| Av.     | .....               | .....           | .....          | 0.64   | 4.00                    | 1.64              | .0016    | .0364       | .0174      | .0190      | .16       | .0110       | .0000     | .6141            | 1.0       |

*Averages by Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 1.25 | 4.23 | 1.89 | .0027 | .0360 | -     | -     | .16 | .0075 | -     | -     | -   |
| - | 1888† | - | - | 0.80 | 3.22 | 1.17 | .0010 | .0157 | -     | -     | .11 | .0127 | .0000 | -     | -   |
| - | 1894  | - | - | 0.45 | 3.75 | 1.39 | .0019 | .0179 | .0112 | .0067 | .11 | .0048 | .0000 | .4750 | 0.9 |
| - | 1895  | - | - | 0.64 | 4.00 | 1.64 | .0016 | .0364 | .0174 | .0190 | .16 | .0110 | .0000 | .6141 | 1.0 |

\* June and December.

† January to March.

NOTE to analyses of 1895: Odor, generally faintly vegetable; grassy in September. — The samples were collected from the reservoir.

*Microscopical Examination of Water from the Large Reservoir in Phillipston.*

[Number of organisms per cubic centimeter.]

|                               | 1895. |       |       |       |       |        |       |
|-------------------------------|-------|-------|-------|-------|-------|--------|-------|
|                               | Jan.  | Feb.  | Mar.  | May.  | July. | Sept.  | Nov.  |
| Day of examination, . . . . . | 9     | 14    | 13    | 9     | 18    | 19     | 22    |
| Number of sample, . . . . .   | 13025 | 13803 | 13954 | 14265 | 14639 | 15213  | 15587 |
| <b>PLANTS.</b>                |       |       |       |       |       |        |       |
| Diatomaceæ, . . . . .         | 4     | 0     | 0     | 19    | 0     | 800    | 552   |
| Asterionella, . . . . .       | 0     | 0     | 0     | 0     | 0     | 0      | 28    |
| Melosira, . . . . .           | 0     | 0     | 0     | 14    | 0     | 800    | 488   |
| Synedra, . . . . .            | 4     | 0     | 0     | 5     | 0     | 0      | 36    |
| Cyanophyceæ, . . . . .        | 5     | 0     | 0     | 0     | 1,760 | 32,000 | 700   |
| Anabaena, . . . . .           | 0     | 0     | 0     | 0     | 1,760 | 32,000 | 700   |
| Aphanocapsa, . . . . .        | 5     | 0     | 0     | 0     | 0     | 0      | 0     |

## ATHOL.

*al Examination of Water from the Large Reservoir in Phillipston—*  
Concluded.

[Number of organisms per cubic centimeter.]

|                        | 1895. |      |       |      |       |        |       |
|------------------------|-------|------|-------|------|-------|--------|-------|
|                        | Jan.  | Feb. | Mar.  | May. | July  | Sept.  | Nov.  |
| PLANTS — Con.          |       |      |       |      |       |        |       |
| . . . . .              | 0     | 0    | 4     | 0    | 0     | 50     | 7     |
| <sub>1</sub> . . . . . | 0     | 0    | 0     | 0    | 0     | 50     | 3     |
| <sub>2</sub> . . . . . | 0     | 0    | 0     | 0    | 0     | 0      | 4     |
| <sub>3</sub> . . . . . | 0     | 0    | 4     | 0    | 0     | 0      | 0     |
| othrix, . . . . .      | 0     | 0    | 0     | 1    | 31    | 0      | 3     |
| ANIMALS.               |       |      |       |      |       |        |       |
| . . . . .              | 194   | 342  | 2,027 | 0    | 2     | 100    | 20    |
| <sub>1</sub> . . . . . | 144   | 5    | 0     | 0    | 0     | 0      | 0     |
| cases, . . . . .       | 34    | 61   | 1,600 | 0    | 0     | 0      | 0     |
| <sub>2</sub> . . . . . | 9     | 156  | 84    | 0    | 0     | 0      | 0     |
| <sub>3</sub> . . . . . | 0     | 4    | 3     | 0    | 0     | 0      | 0     |
| <sub>4</sub> . . . . . | 0     | 0    | 0     | 0    | 0     | 50     | 0     |
| <sub>5</sub> . . . . . | 0     | 0    | 0     | 0    | 0     | 50     | 0     |
| <sub>6</sub> . . . . . | 6     | 112  | 340   | 0    | 0     | 0      | 19    |
| onas, . . . . .        | 1     | 1    | 0     | 0    | 2     | 0      | 1     |
| . . . . .              | 1     | 3    | 1     | 0    | 0     | 0      | 1     |
| . . . . .              | 0     | 1    | 0     | 0    | 0     | 0      | 1     |
| <sub>1</sub> . . . . . | 0     | 1    | 0     | 0    | 0     | 0      | 0     |
| <sub>2</sub> . . . . . | 0     | 0    | 1     | 0    | 0     | 0      | 0     |
| OVA, . . . . .         | 0     | 1    | 0     | 0    | 0     | 0      | 0     |
| . . . . .              | 1     | 0    | 0     | 0    | 0     | 0      | 0     |
| . . . . .              | 0     | 0    | 0     | 20   | 0     | 0      | .04   |
| . . . . .              | 0     | 0    | 0     | 0    | 0     | 0      | .04   |
| . . . . .              | 0     | 0    | 0     | 20   | 0     | 0      | 0     |
| . . . . .              | 204   | 345  | 2,032 | 40   | 1,793 | 32,950 | 1,233 |

*Chemical Examination of Water from Newton Reservoir, Athol.*

[Parts per 100,000.]

| APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
| Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| V. slight.  | Slight.   | .30    | 2.95                            | 1.10                 | .0000    | .0108       | .0086      | .0022           | .13       | .0070          | .0001     | .3588            | 0.9       |

y faintly vegetable, disappearing on heating.—The sample was collected from the

*Microscopical Examination.*

as, *Asterionella*, 8; *Melosira*, 3; *Synedra*, 2. Algæ, *Glæocapsa*, 3; *Protococcus*, 14; Fungi, *Crenothrix*, 1. Infusoria, *Dinobryon*, 125; *Dinobryon* cases, 14; *Peridinium*, *Daphnia*, .04. Total, 239.

## ATTLEBOROUGH.

*Chemical Examination of Water from Faucets in Attleborough supplied from the Attleborough Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                   |        | Residue on Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|---------------------|-------------------|--------|-------------------------|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.          | Sediment.         | Color. |                         | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | 1895.               |                     |                   |        |                         |          |                  |           |             |           |                  |           |       |
| 4787    | Aug. 7              | Distinct.           | Cons.,<br>rusty.  | .00    | 4.20                    | .0000    | .0018            | .33       | .0150       | .0000     | .0468            | 2.6       | .3000 |
| 4788    | Aug. 7              | Decided,<br>rusty   | Heavy,<br>rusty.  | .08    | 6.30                    | .0000    | .0020            | .33       | .0080       | .0001     | .0390            | 2.3       | .6000 |
| 4969    | Sept. 4             | Slight,<br>milky.   | Slight,<br>rusty. | .10    | 3.60                    | .0000    | .0026            | .37       | .0010       | .0003     | .0693            | 1.7       | .0550 |
| 4970    | Sept. 4             | Decided,<br>yellow. | Cons.,<br>rusty.  | .02    | 5.00                    | .0000    | .0036            | .39       | .0050       | .0003     | .0755            | 2.5       | .2900 |

Odor of the first sample, very faintly earthy, becoming stronger on heating; of the second, decidedly tarry; of the third, distinct, fragrant, disappearing on heating; of the last, none, becoming distinctly vegetable and unpleasant on heating. — The samples were collected from hydrants on dead ends, the first and last on Forest street; the second 400 feet off force main from the pumping station to the sandpipe; the third, on Robert Street. The hydrant on Robert Street was flushed the day before the sample was collected.

*Microscopical Examination.*No. 14787, Fungi, *Crenothrix*, 8,000.No. 14788, Fungi, *Crenothrix*, 3,960.No. 14969, Fungi, *Crenothrix*, 162.No. 14970, Fungi, *Crenothrix*, 4,300.*Chemical Examination of Water from Orr's Pond, Attleborough.*

[Parts per 100,000.].

| DATE OF COLLECTION. | APPEARANCE.      |               |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed | Hardness. |
|---------------------|------------------|---------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|-----------------|-----------|
|                     | Turbidity.       | Sediment.     | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                 |           |
|                     |                  |               |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                 |           |
|                     |                  |               |        |                         |                   |          |             |            |            |           |             |           |                 |           |
| 1895.               |                  |               |        |                         |                   |          |             |            |            |           |             |           |                 |           |
| 82 Mar. 14          | Distinct.        | Slight.       | .50    | 3.15                    | 1.50              | .0008    | .0270       | .0254      | .0016      | .30       | .0050       | .0000     | .6064           | 0.6       |
| 17 Sept. 7          | Slight.          | Slight.       | .70    | 5.60                    | 2.00              | .0016    | .0350       | .0332      | .0018      | .38       | .0000       | .0002     | .8112           | 1.9       |
| 18 Sept. 30         | Distinct, green. | Slight, green | .60    | 3.85                    | 1.95              | .0006    | .0370       | .0350      | .0020      | .36       | .0030       | .0000     | .6474           | 1.1       |
| 14 Oct. 9           | V slight.        | Slight.       | .40    | 3.75                    | 2.00              | .0014    | .0354       | .0334      | .0020      | .36       | .0000       | .0000     | .6146           | 1.4       |
| .....               | .....            | .....         | .55    | 4.09                    | 1.86              | .0011    | .0336       | .0318      | .0018      | .35       | .0020       | .0001     | .6699           | 1.3       |

Odor of the second sample, none; of the other samples, distinctly vegetable, mouldy or grassy. Orr's Pond is located just below the well of the Attleborough Water Works, at the confluence of an Mile River and Four Mile Brook.

*Microscopical Examination.*

The number of organisms per cubic centimeter found in each of these samples was as follows: No. 2, 8; No. 15047, 33; No. 15278, 257; No. 15344, 234.

## AVON.

## WATER SUPPLY OF AVON.

*Chemical Examination of Water from the Well of the Avon Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         |                     |             |           |        |                         |          |                  |           |             |           |                  |           |       |
| 15125   | 1895.<br>Sept. 9    | None.       | None.     | .00    | 4.00                    | .0002    | .0002            | .48       | .0350       | .0000     | .0390            | 0.8       | .0020 |

Odor, none. — The sample was collected from a faucet at the pumping station while pumping.

*Microscopical Examination.*

No organisms.

## WATER SUPPLY OF AYER.

*Chemical Examination of Water from the Well of the Ayer Water Works.*

[Parts per 100,000.]

| Number. | Date of<br>Collection. | APPEARANCE. |           |        | Residue on<br>Evaporation. | AMMONIA. |                 | Chlorine, | NITROGEN<br>AS |           | Oxygen<br>Consumed. | Hardness. | Iron. |
|---------|------------------------|-------------|-----------|--------|----------------------------|----------|-----------------|-----------|----------------|-----------|---------------------|-----------|-------|
|         |                        | Turbidity.  | Sediment. | Color. |                            | Free.    | Albu-<br>minoid |           | Nitrates.      | Nitrites. |                     |           |       |
|         |                        |             |           |        |                            |          |                 |           |                |           |                     |           |       |
| 14546   | 1895.<br>June 26       | None.       | None.     | .00    | 6.60                       | .0000    | .0012           | .40       | .0450          | .0000     | .0231               | 2.7       | .0000 |
| 14932   | Aug. 28                | None.       | None.     | .00    | 6.00                       | .0000    | .0004           | .60       | .0750          | .0000     | .0000               | 2.3       | .0030 |
| 15433   | Oct. 28                | None.       | Slight.   | .02    | 6.30                       | .0026    | .0018           | .50       | .0800          | .0000     | .0218               | 2.7       | .0010 |
| Av.     | .....                  | .....       | .....     | .01    | 6.30                       | .0009    | .0011           | .50       | .0667          | .0000     | .0150               | 2.6       | .0013 |

Odor, none. — The first and second samples were collected from a faucet at the pumping station; the last, from the well.

*Microscopical Examination.*

An insignificant number of organisms was found in these samples.

BARRE.

WATER SUPPLY OF BARRE.

Population in 1895, 2,278. The works are owned by the Barre Water Company and were completed in October, 1895. The source of supply is a small storage reservoir in the northerly part of the town in which the water from several springs in the vicinity is collected. Water from springs in another watershed is also diverted to this reservoir by means of 700 feet of open trench and about 100 feet of earthen pipe.

The combined watersheds tributary to the storage reservoir contain about 275 acres of hilly country, half of which is wooded, the remainder being largely pasture land. There are a few houses on the watersheds.

The storage reservoir was made by excavating in a depression and building a dyke around the edges, material for the dyke being taken from the excavation. The bottom of the reservoir is of hard pan. The area when full is 4.25 acres, its depth 10 feet, and its capacity 1,000,000 gallons.

Water is distributed by gravity. Distributing mains are of cast iron and service pipes of wrought iron lined with cement.

The advice of the State Board of Health to the Barre Water Company relative to taking water from this source as a public water supply may be found on pages 8 and 9 of the annual report for 1894, and analyses of samples of water collected during the investigation with reference to a water supply may be found on page 83 of the same volume.

WATER SUPPLY OF BELMONT.

(See *Watertown.*)

WATER SUPPLY OF BEVERLY.

(See *Salem.*)

BILLERICA.

The advice of the State Board of Health to J. Nelson Parker and others of the town of Billerica, with reference to the use of Nutting's pond in that town as a source of public water supply, may be found on pages 14 and 15 of this volume. Analyses of samples of water collected at different parts of the pond are given on the following page.



**BILLERICA.***Chemical Examination of Water from Nutting's Pond, Billerica.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                |        | RESIDUE ON EVAPORATION. |                  | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|----------------|--------|-------------------------|------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.      | Color. | Total.                  | Loss on Ignition | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                |        |                         |                  |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 14052   | 1895.<br>Mar. 28    | Distinct.   | Slight, green. | 0.70   | 4.05                    | 1.55             | .0030    | .0290       | .0184      | .0106      | .32       | .0070       | .0001     | .7238            | 1.6       |
| 14723   | July 27             | Slight.     | Slight.        | 0.85   | 4.15                    | 1.90             | .0026    | .0260       | .0246      | .0014      | .47       | .0070       | .0000     | .4158            | 1.7       |
| 15225   | Sept. 20            | Slight.     | Slight.        | 0.67   | 4.45                    | 2.05             | .0000    | .0232       | .0222      | .0010      | .46       | .0050       | .0000     | .6396            | 0.9       |
| 15226   | Sept. 20            | Distinct.   | Slight.        | 0.63   | 4.30                    | 1.85             | .0006    | .0236       | .0230      | .0006      | .44       | .0060       | .0000     | .6162            | 0.9       |
| 15227   | Sept. 20            | Slight.     | Slight.        | 1.10   | 5.35                    | 2.40             | .0002    | .0296       | .0284      | .0012      | .48       | .0070       | .0000     | .9477            | 1.6       |

Odor, vegetable, becoming stronger on heating. — The samples were collected from the pond at different points, as follows: No. 14052 at the causeway where the pond is crossed by the Middlesex turnpike; No. 14723 from the west side near the road; No. 15225 from west end of west half of pond; No. 15226 from east end of west half of pond. No. 15227 from middle of east half of pond.

*Microscopical Examination of Water from Nutting's Pond, Billerica.*

[Number of organisms per cubic centimeter.]

|                               | 1895.  |       |       |       |       |
|-------------------------------|--------|-------|-------|-------|-------|
|                               | March. | July. | Sept. | Sept. | Sept. |
| Day of examination, . . . . . | 30     | 31    | 21    | 21    | 21    |
| Number of sample, . . . . .   | 14052  | 14723 | 15225 | 15226 | 15227 |
| <b>PLANTS.</b>                |        |       |       |       |       |
| Diatomaceæ, . . . . .         | 0      | 2     | 1     | 5     | 32    |
| Melosira, . . . . .           | 0      | 0     | 0     | 5     | 32    |
| Synedra, . . . . .            | 0      | 2     | 1     | 0     | 0     |
| Cyanophyceæ, . . . . .        | 0      | 17    | 79    | 7     | 7     |
| Merismopedia, . . . . .       | 0      | 6     | 49    | 0     | 0     |
| Microcystis, . . . . .        | 0      | 11    | 30    | 7     | 7     |
| Algæ, Protococcus, . . . . .  | 320    | 0     | 35    | 0     | 0     |
| <b>ANIMALS.</b>               |        |       |       |       |       |
| Infusoria, . . . . .          | 312    | 3     | 2     | 0     | 0     |
| Codonella, . . . . .          | 0      | 0     | 1     | 0     | 0     |
| Cryptomonas, . . . . .        | 200    | 0     | 0     | 0     | 0     |
| Dinobryon, . . . . .          | 4      | 0     | 0     | 0     | 0     |
| Dinobryon cases, . . . . .    | 8      | 0     | 0     | 0     | 0     |
| Mallomonas, . . . . .         | 0      | 1     | 0     | 0     | 0     |
| Synura, . . . . .             | 100    | 0     | 0     | 0     | 0     |
| Tintinnidium, . . . . .       | 0      | 2     | 1     | 0     | 0     |

BILLERICA.

*Microscopical Examination of Water from Nutting's Pond, Billerica* — Concluded.

[Number of organisms per cubic centimeter.]

|                               | 1895.      |           |            |           |           |
|-------------------------------|------------|-----------|------------|-----------|-----------|
|                               | March.     | July.     | Sept.      | Sept.     | Sept.     |
| <b>ANIMALS—Con.</b>           |            |           |            |           |           |
| Amoebae, . . . . .            | 0          | 0         | 0          | 1         | 1         |
| Anurae, . . . . .             | 0          | 0         | 0          | 0         | 1         |
| Rotatorian ova, . . . . .     | 0          | 0         | 0          | 1         | 0         |
| Crustacea, Cyclops, . . . . . | 0          | .04       | 0          | 0         | 0         |
| Mollusca, Acarina, . . . . .  | 0          | 0         | 0          | 0         | .10       |
| <b>TOTAL, . . . . .</b>       | <b>632</b> | <b>22</b> | <b>117</b> | <b>13</b> | <b>40</b> |

WATER SUPPLY OF BOSTON.

The results of analyses of water from reservoir No. 6 given on pages 98–101 indicate that the quality has remained about the same last year, that there has been no large growth of organisms and that during the period of summer stagnation there has been only a comparatively small accumulation of the products of decomposition at the bottom of the reservoir.

The color of the water supplied to the city from the Cochituate works in 1895, as indicated by the averages of analyses given on page 115, again shows a slight increase over the previous year. The higher color of recent years is due, as noted in previous reports, to the increasing proportion of Sudbury River water supplied to the city.

As stated in the annual report for 1894, the odor of the water of Mystic Lake became extremely offensive in the latter part of 1894 and early in 1895, so that many of the water consumers found it necessary to obtain well or spring water for drinking. This condition continued through the winter for a period of several weeks, but the quality of the water improved with the breaking up of the ice on the lake.

The water of Stony Brook above Reservoir No. 3, and of the reservoir itself, has been unfavorably affected, during this year as it, by work incidental to the construction of Dam No. 5 and the tipping of the basin to be formed by this dam. In consequence of this work the use of water from reservoir No. 3 has been avoided, as far as possible.

## BOSTON.

SUDBURY RIVER SUPPLY.—*Chemical Examination of Water from Indian Brook at Head of Reservoir No. 6, Hopkinton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.   |                     |             |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 13562   | Jan. 1              | V. slight.  | V. slight. | 1.80   | 6.75                            | 3.60                 | .0010    | .0300       | .0282      | .0018           | 1.02      | .0000          | .0000     | 1.8865           | 1.9       |
| 13740   | Feb. 4              | V. slight.  | V. slight. | 1.80   | 6.45                            | 3.45                 | .0000    | .0276       | .0258      | .0018           | .51       | .0070          | .0000     | 2.3305           | 1.7       |
| 13906   | Mar. 4              | V. slight.  | V. slight. | 1.30   | 5.50                            | 2.30                 | .0016    | .0276       | .0240      | .0020           | .57       | .0070          | .0000     | 1.2998           | 1.7       |
| 14059   | Apr. 1              | V. slight.  | V. slight. | 1.30   | 3.65                            | 2.30                 | .0006    | .0250       | .0206      | .0044           | .31       | .0030          | .0001     | 0.9586           | 0.8       |
| 14229   | May 1               | V. slight.  | Slight.    | 1.80   | 4.90                            | 2.75                 | .0012    | .0312       | .0274      | .0038           | .47       | .0020          | .0001     | 1.8711           | 1.3       |
| 14399   | June 3              | Slight.     | Slight.    | 3.00   | 7.20                            | 4.00                 | .0018    | .0478       | .0454      | .0024           | .35       | .0020          | .0000     | 2.5460           | 1.9       |
| 14565   | July 1              | V. slight.  | Slight.    | 1.80   | 6.35                            | 3.20                 | .0012    | .0428       | .0392      | .0036           | .43       | .0000          | .0001     | 1.6353           | 1.6       |
| 14742   | Aug. 1              | Slight.     | Slight.    | 1.90   | 8.30                            | 5.15                 | .0008    | .0620       | .0580      | .0040           | .55       | .0000          | .0000     | 2.7720           | 2.3       |
| 14942   | Sept. 2             | V. slight.  | V. slight. | 1.60   | 7.15                            | 3.50                 | .0010    | .0408       | .0386      | .0022           | .77       | .0020          | .0000     | 1.9404           | 1.8       |
| 15281   | Oct. 1              | Slight.     | Slight.    | 1.10   | 7.25                            | 2.80                 | .0000    | .0390       | .0326      | .0064           | .83       | .0030          | .0000     | 1.2129           | 1.9       |
| 15462   | Nov. 4              | None.       | V. slight  | 1.80   | 6.05                            | 3.70                 | .0002    | .0338       | .0315      | .0020           | .62       | .0070          | .0001     | 2.2776           | 1.3       |
| 15646   | Dec. 2              | None.       | V. slight. | 1.50   | 4.50                            | 2.55                 | .0004    | .0214       | .0194      | .0020           | .36       | .0020          | .0000     | 1.3416           | 0.8       |
| Av.     | 1895                | .....       | .....      | 1.72   | 6.17                            | 3.28                 | .0008    | .0358       | .0327      | .0031           | .56       | .0029          | .0000     | 1.8394           | 1.6       |
| Av.     | 1894                | .....       | .....      | 2.16   | 6.58                            | 3.38                 | .0014    | .0323       | .0300      | .0024           | .54       | .0018          | .0000     | 1.7889           | 1.6       |

NOTE to analyses of 1895: Odor, generally vegetable and frequently also mouldy. — The samples were collected from the brook, at its entrance into Reservoir No. 6.

*Microscopical Examination.*

The average number of organisms per cubic centimeter found in these samples was 75.

SUDBURY RIVER SUPPLY.—*Chemical Examination of Water from Reservoir No. 6, Ashland, collected near the Surface.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment.       | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                     |                 |        |                         |                   |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |           |
| 1895.   |                     |                     |                 |        |                         |                   |          |             |            |                 |           |             |           |                  |           |
| 13564   | Jan. 1              | V. slight.          | V. slight.      | 0.75   | 4.40                    | 2.05              | .0034    | .0234       | .0224      | .0010           | .43       | .0020       | .0000     | .6930            | 1.4       |
| 14060   | Apr. 1              | Distinct.           | Slight.         | 0.75   | 4.15                    | 1.95              | .0038    | .0214       | .0204      | .0010           | .41       | .0100       | .0001     | .7584            | 1.1       |
| 14230   | May 1               | V. slight.          | Slight.         | 0.90   | 4.20                    | 2.00              | .0030    | .0176       | .0166      | .0010           | .35       | .0100       | .0001     | .7492            | 1.4       |
| 14401   | June 3              | Distinct.<br>green. | Slight.         | 0.73   | 4.05                    | 1.50              | .0010    | .0272       | .0212      | .0060           | .39       | .0050       | .0001     | .7410            | 1.3       |
| 14566   | July 1              | Slight              | Cons.           | 0.68   | 4.30                    | 1.95              | .0002    | .0246       | .0222      | .0024           | .38       | .0030       | .0000     | .7244            | 1.1       |
| 14743   | Aug. 1              | Distinct.<br>green. | Cons.<br>green. | 0.53   | 4.20                    | 1.30              | .0000    | .0244       | .0208      | .0036           | .37       | .0000       | .0000     | .7007            | 2.1       |
| 14943   | Sept. 2             | Distinct.           | Slight.         | 0.45   | 3.95                    | 1.60              | .0000    | .0222       | .0182      | .0040           | .40       | .0030       | .0000     | .6252            | 1.1       |
| 15282   | Oct. 1              | Distinct.           | Slight.         | 0.40   | 3.80                    | 1.55              | .0000    | .0226       | .0190      | .0036           | .39       | .0030       | .0000     | .5538            | 1.3       |
| 15461   | Nov. 4              | Distinct.           | Slight.         | 1.00   | 4.25                    | 2.45              | .0018    | .0260       | .0232      | .0028           | .46       | .0070       | .0001     | 1.0374           | 1.1       |
| 15647   | Dec. 2              | Distinct.           | Slight.         | 1.10   | 4.25                    | 2.30              | .0034    | .0294       | .0262      | .0032           | .35       | .0050       | .0000     | 1.0335           | 0.9       |
| Av.     | 1895                | .....               | .....           | 0.73   | 4.15                    | 1.86              | .0017    | .0239       | .0210      | .0029           | .40       | .0048       | .0000     | .7617            | 1.3       |
| Av.     | 1894                | .....               | .....           | 0.79   | 3.93                    | 1.59              | .0013    | .0191       | .0166      | .0025           | .40       | .0040       | .0001     | .7466            | 1.2       |

NOTE to analyses of 1895: Odor, vegetable, frequently also unpleasant or disagreeable. The iron was determined in five samples, the average amount in parts per 100,000 being .0139. — The samples were collected from the reservoir near the dam. For monthly record of height of water in this reservoir see table at end of Boston analyses.

No. 34.] EXAMINATION OF WATER SUPPLIES.

BOSTON.

SUDBURY RIVER SUPPLY.—*Microscopical Examination of Water from Reservoir No. 6, Ashland, collected near the Surface.*

[Number of organisms per cubic centimeter.]

|                                   | 1895. |       |       |       |       |       |       |       |       |       |
|-----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                   | Jan.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . . .     | 2     | 2     | 2     | 4     | 2     | 2     | 4     | 2     | 5     | 3     |
| Number of sample, . . . . .       | 13564 | 14060 | 14230 | 14401 | 14566 | 14743 | 14943 | 15282 | 15461 | 15647 |
| PLANTS.                           |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . . .             | 3     | 0     | 4     | 1,133 | 722   | 1,689 | 29    | 143   | 41    | 17    |
| Cyclotella, . . . . .             | 0     | 0     | 0     | 21    | 680   | 1,680 | 15    | 136   | 40    | 11    |
| Diatoma, . . . . .                | 0     | 0     | 0     | 0     | 0     | 0     | 8     | 1     | 0     | 4     |
| Melosira, . . . . .               | 0     | 0     | 0     | 30    | 0     | 0     | 0     | 0     | 0     | 0     |
| Navicula, . . . . .               | 0     | 0     | 0     | 6     | 0     | 0     | 1     | 0     | 0     | 0     |
| Synedra, . . . . .                | 3     | 0     | 4     | 1,072 | 32    | 0     | 0     | 2     | 1     | 2     |
| Tabellaria, . . . . .             | 0     | 0     | 0     | 4     | 10    | 9     | 7     | 4     | 0     | 0     |
| Dyanophyceæ, Anabæna, . . . . .   | 0     | 0     | 0     | 0     | 0     | 52    | 0     | 0     | 0     | 0     |
| Algæ, . . . . .                   | 14    | 0     | 1     | 28    | 4     | 4     | 321   | 455   | 21    | 31    |
| Arthrodesmus, . . . . .           | 0     | 0     | 0     | 4     | 4     | 0     | 0     | 3     | 1     | 1     |
| Chlorococcus, . . . . .           | 14    | 0     | 0     | 0     | 0     | 0     | 7     | 5     | 0     | 0     |
| Glæocapsa, . . . . .              | 0     | 0     | 0     | 0     | 0     | 2     | 4     | 0     | 0     | 0     |
| Protococcus, . . . . .            | 0     | 0     | 1     | 24    | 0     | 0     | 204   | 432   | 12    | 13    |
| Raphidium, . . . . .              | 0     | 0     | 0     | 0     | 0     | 0     | 96    | 14    | 8     | 17    |
| Staurastrum, . . . . .            | 0     | 0     | 0     | 0     | 0     | 2     | 5     | 0     | 0     | 0     |
| Staurigenia, . . . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 5     | 1     | 0     | 0     |
| ANIMALS.                          |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . . . .              | 10    | 43    | 7     | 76    | 9     | 0     | 3     | 18    | 0     | 3     |
| Cryptomonas, . . . . .            | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon, . . . . .              | 0     | 32    | 2     | 54    | 0     | 0     | 0     | 15    | 0     | 0     |
| Dinobryon cases, . . . . .        | 0     | 10    | 1     | 22    | 0     | 0     | 0     | 0     | 0     | 0     |
| Peridinium, . . . . .             | 7     | 1     | 1     | 0     | 3     | 0     | 1     | 0     | 0     | 3     |
| Synura, . . . . .                 | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Trachelomonas, . . . . .          | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 2     | 0     | 0     |
| Vorticella, . . . . .             | 0     | 0     | 0     | 0     | 6     | 0     | 1     | 1     | 0     | 0     |
| ermes, Rotifer, . . . . .         | 0     |       | 0     | 0     | 0     | 0     | 0     | 0     | 5     | 0     |
| Miscellaneous, Zoöglæa, . . . . . | 0     | 1     | 0     | 0     | 0     | 0     | 3     | 100   | 19    | 5     |
| TOTAL, . . . . .                  | 27    | 46    | 12    | 1,237 | 735   | 1,745 | 356   | 716   | 86    | 56    |

BOSTON.

NEEDHAM RIVER SUPPLY.—*Microscopical Examination of Water from Reservoir No. 6, Ashland, collected near the Bottom.*

[Number of organisms per cubic centimeter.]

|                             | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|-----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                             | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .   | 2     | 5     | 5     | 2     | 2     | 4     | 2     | 2     | 4     | 2     | 5     | 3     |
| Number of sample, . . .     | 13563 | 13742 | 13908 | 14061 | 14231 | 14400 | 14567 | 14744 | 14944 | 15283 | 15463 | 15648 |
| PLANTS.                     |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . .         | 30    | 0     | 4     | 1     | 8     | 49    | 35    | 1,084 | 100   | 211   | 36    | 4     |
| Cyclotella, . . . .         | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 1,080 | 96    | 208   | 23    | 2     |
| Diatoma, . . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 2     | 0     | 2     |
| Melosira, . . . .           | 0     | 0     | 0     | 1     | 0     | 2     | 4     | 0     | 0     | 0     | 0     | 0     |
| Synedra, . . . .            | 26    | 0     | 4     | 0     | 6     | 42    | 28    | 2     | 0     | 0     | 0     | 0     |
| Tabellaria, . . . .         | 4     | 0     | 0     | 0     | 0     | 3     | 3     | 2     | 0     | 1     | 8     | 0     |
| Algae, . . . .              | 0     | 0     | 0     | 0     | 6     | 14    | 0     | 0     | 0     | 264   | 28    | 52    |
| Protococcus, . . . .        | 0     | 0     | 0     | 0     | 6     | 14    | 0     | 0     | 0     | 260   | 16    | 0     |
| Raphidium, . . . .          | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 12    | 52    |
| Fungi, Crenothrix, . . .    | 0     | 0     | 4     | 0     | 0     | 18    | 9     | 0     | 10    | 1     | 0     | 0     |
| ANIMALS.                    |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . . .          | 1     | 3     | pr.   | 102   | 3     | 0     | 2     | 24    | 0     | 10    | 1     | 0     |
| Conochilus, . . . .         | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     |
| Dinobryon, . . . .          | 0     | 0     | 0     | 58    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, . . .      | 0     | 0     | 0     | 44    | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Peridinium, . . . .         | 1     | 1     | pr.   | 0     | 1     | 0     | 0     | 24    | 0     | 0     | 0     | 0     |
| Synura, . . . .             | 0     | 1     | 0     | pr.   | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Tintinnidium, . . . .       | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     |
| Trachelomonas, . . . .      | 0     | 1     | pr.   | 0     | 0     | 0     | 1     | 0     | 0     | 5     | 1     | 0     |
| Vorticella, . . . .         | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 1     | 0     | 0     |
| Terms, Rotifer, . . . .     | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 1     | 0     |
| Miscellaneous, Zoöglæa, . . | 0     | 0     | 74    | 0     | 0     | 0     | 0     | 0     | 1,680 | 200   | 20    | 0     |
| TOTAL, . . . .              | 31    | 3     | 82    | 103   | 16    | 81    | 46    | 1,108 | 1,790 | 686   | 86    | 56    |

## BOSTON.

SUDBURY RIVER SUPPLY.—*Chemical Examination of Water from Cold Spring Brook, at Head of Reservoir No. 4, Ashland.*

[Parts per 100,000]

| Number.  | Date of Collection | APPEARANCE.       |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|----------|--------------------|-------------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|          |                    | Turbidity.        | Sediment.       | Color. | Total.                  | Lost on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|          |                    |                   |                 |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.    |                    |                   |                 |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 13565    | Jan. 1             | V. slight.        | V. slight.      | 1.50   | 5.35                    | 2.45              | .0008    | .0260       | .0240      | .0020      | .34       | .0030       | .0000     | 1.3860           | 1.7       |
| 13748    | Feb. 4             | V. slight.        | Slight.         | 1.30   | 5.10                    | 2.25              | .0028    | .0260       | .0228      | .0032      | .35       | .0070       | .0000     | 1.3825           | 1.1       |
| 13909    | Mar. 4             | V. slight.        | Slight.         | 1.05   | 4.55                    | 1.80              | .0002    | .0232       | .0220      | .0012      | .33       | .0070       | .0000     | .9610            | 1.1       |
| 14062    | Apr. 1             | Slight.           | V. slight.      | 1.10   | 3.70                    | 2.25              | .0002    | .0258       | .0230      | .0028      | .36       | .0030       | .0000     | .9086            | 0.8       |
| 14220    | May 1              | V. slight.        | V. slight.      | 1.50   | 4.60                    | 2.75              | .0000    | .0340       | .0294      | .0046      | .36       | .0020       | .0001     | 1.2320           | 1.3       |
| 14402    | June 3             | Distinct.         | Slight.         | 1.30   | 4.20                    | 2.30              | .0012    | .0300       | .0282      | .0018      | .27       | .0030       | .0001     | 1.0530           | 0.9       |
| 14568    | July 1             | Slight.           | Slight.         | 0.90   | 3.85                    | 1.95              | .0004    | .0276       | .0252      | .0024      | .31       | .0000       | .0000     | .8469            | 1.1       |
| 14745    | Aug. 1             | Slight.           | Slight.         | 0.90   | 5.45                    | 2.65              | .0000    | .0292       | .0284      | .0008      | .32       | .0070       | .0000     | 1.0703           | 1.6       |
| 14949    | Sept. 3            | V. slight.        | Slight.         | 0.70   | 4.35                    | 2.15              | .0004    | .0214       | .0198      | .0016      | .34       | .0030       | .0000     | .8006            | 1.2       |
| 15284    | Oct. 1             | Distinct, clayey. | Slight, earthy. | 0.50   | 3.55                    | 1.45              | .0012    | .0250       | .0202      | .0048      | .31       | .0030       | .0000     | .5616            | 1.1       |
| 15464    | Nov. 4             | V. slight.        | V. slight.      | 1.85   | 6.90                    | 4.40              | .0000    | .0446       | .0426      | .0020      | .32       | .0030       | .0001     | 2.3244           | 1.6       |
| 15649    | Dec. 2             | V. slight.        | V. slight.      | 1.70   | 4.80                    | 2.95              | .0006    | .0292       | .0274      | .0018      | .21       | .0000       | .0000     | 1.5444           | 0.9       |
| Av. .... | .....              | .....             | .....           | 1.19   | 4.70                    | 2.45              | .0006    | .0285       | .0261      | .0024      | .32       | .0034       | .0000     | 1.1584           | 1.2       |

*Averages by Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |        |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|--------|-----|
| - | 1889* | - | - | 2.24 | -    | -    | .0025 | .0410 | .0385 | .0025 | .28 | .0056 | .0001 | -      | -   |
| - | 1890  | - | - | 0.91 | 4.40 | 2.01 | .0011 | .0243 | .0210 | .0033 | .24 | .0090 | .0001 | -      | 1.5 |
| - | 1891  | - | - | 1.30 | 4.87 | 2.30 | .0009 | .0297 | .0262 | .0035 | .23 | .0087 | .0001 | -      | 1.3 |
| - | 1892  | - | - | 1.44 | 5.15 | 2.57 | .0003 | .0308 | .0266 | .0042 | .25 | .0068 | .0001 | -      | 1.2 |
| - | 1893  | - | - | 1.23 | 4.52 | 2.16 | .0013 | .0248 | .0212 | .0036 | .26 | .0031 | .0001 | .9768  | 1.3 |
| - | 1894  | - | - | 1.44 | 4.94 | 2.42 | .0007 | .0237 | .0214 | .0023 | .31 | .0043 | .0000 | 1.1962 | 1.2 |
| - | 1895  | - | - | 1.19 | 4.70 | 2.45 | .0006 | .0285 | .0261 | .0024 | .32 | .0034 | .0000 | 1.1584 | 1.2 |

\* June to December.

NOTE to analyses of 1895: Odor, vegetable.—The samples were collected from the brook at the entrance into Reservoir No. 4.

*Microscopical Examination.*

The average number of organisms per cubic centimeter found in these samples was 68.

## BOSTON.

RIVER SUPPLY.—*Chemical Examination of Water from Reservoir No. 4, Ashland.*

[Parts per 100,000.]

| APPEARANCE.          |                    |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. |     | Hardness. |
|----------------------|--------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----|-----------|
| Turbidity.           | Sediment.          | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |     |           |
|                      |                    |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |     |           |
| Slight.              | Slight.            | 1.00   | 4.75                            | 1.90                 | .0036    | .0298       | .0282      | .0036           | .37       | .0020          | .0000     | .9432            | 1.7 |           |
| V. slight.           | V. slight.         | 1.30   | 5.70                            | 2.55                 | .0032    | .0270       | .0252      | .0018           | .43       | .0180          | .0000     | 1.3983           | 1.3 |           |
| V. slight.           | V. slight.         | 0.85   | 4.25                            | 1.70                 | .0072    | .0210       | .0204      | .0006           | .32       | .0100          | .0000     | .8455            | 1.4 |           |
| V. slight.           | V. slight.         | 0.90   | 4.15                            | 2.20                 | .0018    | .0264       | .0240      | .0024           | .34       | .0090          | .0001     | .9355            | 1.3 |           |
| V. slight.           | V. slight.         | 0.90   | 4.15                            | 2.25                 | .0008    | .0208       | .0192      | .0016           | .31       | .0080          | .0000     | .8470            | 1.1 |           |
| Distinct.            | Slight.            | 0.95   | 3.90                            | 2.05                 | .0006    | .0266       | .0244      | .0022           | .29       | .0020          | .0000     | .9424            | 1.1 |           |
| Slight.              | Slight.            | 0.90   | 4.20                            | 2.10                 | .0006    | .0236       | .0202      | .0034           | .28       | .0000          | .0000     | .8113            | 0.9 |           |
| Slight.              | Slight.            | 0.68   | 4.10                            | 1.75                 | .0002    | .0258       | .0240      | .0018           | .30       | .0050          | .0000     | .8008            | 1.3 |           |
| Slight.              | Slight.            | 0.60   | 3.65                            | 1.80                 | .0000    | .0184       | .0168      | .0016           | .33       | .0000          | .0000     | .6684            | 0.6 |           |
| Distinct,<br>clayey. | Slight,<br>earthy. | 0.60   | 3.50                            | 1.70                 | .0000    | .0230       | .0180      | .0050           | .30       | .0030          | .0000     | .6006            | 0.9 |           |
| Distinct.            | Slight.            | 0.90   | 3.95                            | 2.15                 | .0002    | .0238       | .0212      | .0026           | .35       | .0050          | .0002     | .9087            | 1.1 |           |
| Distinct.            | Slight.            | 1.15   | 4.35                            | 2.30                 | .0004    | .0288       | .0278      | .0010           | .21       | .0000          | .0000     | 1.1544           | 0.9 |           |
| .....                | .....              | 0.89   | 4.22                            | 2.04                 | .0015    | .0246       | .0223      | .0023           | .32       | .0052          | .0000     | .9047            | 1.1 |           |

*Averages by Years.*

|   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | - | 0.74 | 3.71 | 1.51 | .0005 | .0246 | -     | -     | .25 | .0033 | -     | -     | -   |
| - | - | 0.72 | 3.83 | 1.70 | .0007 | .0277 | -     | -     | .22 | .0054 | .0001 | -     | -   |
| - | - | 0.85 | 3.48 | 1.98 | .0016 | .0251 | .0218 | .0033 | .23 | .0068 | .0002 | -     | -   |
| - | - | 0.61 | 3.67 | 1.40 | .0008 | .0222 | .0191 | .0031 | .24 | .0096 | .0001 | -     | 1.7 |
| - | - | 0.53 | 3.24 | 1.55 | .0006 | .0187 | .0156 | .0031 | .20 | .0062 | .0001 | -     | 0.9 |
| - | - | 0.64 | 3.60 | 1.52 | .0002 | .0200 | .0168 | .0032 | .23 | .0061 | .0001 | -     | 1.1 |
| - | - | 0.77 | 3.54 | 1.63 | .0024 | .0206 | .0173 | .0033 | .23 | .0048 | .0001 | .6773 | 1.0 |
| - | - | 0.83 | 4.00 | 1.73 | .0027 | .0202 | .0180 | .0022 | .29 | .0045 | .0001 | .7840 | 1.1 |
| - | - | 0.89 | 4.22 | 2.04 | .0015 | .0246 | .0223 | .0023 | .32 | .0052 | .0000 | .9047 | 1.1 |

\* June to December.

analyses of 1895: Odor, vegetable, generally stronger on heating. The iron was determined as, the average amount in parts per 100,000 being .0075.—The samples were collected near the gate-house, 1 foot beneath the surface. For monthly record of height of reservoir see table at end of Boston analyses.

## BOSTON.

SUDBURY RIVER SUPPLY. — *Microscopical Examination of Water from Reservoir No. 4, Ashland.*

[Number of organisms per cubic centimeter.]

|                               | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|-------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                               | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . . . | 2     | 5     | 6     | 3     | 1     | 4     | 3     | 2     | 4     | 2     | 5     | 3     |
| Number of sample, . . . . .   | 13566 | 13749 | 13910 | 14063 | 14221 | 14403 | 14569 | 14746 | 14950 | 15285 | 15465 | 15650 |
| PLANTS.                       |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . . .         | 0     | 1     | 0     | 3     | 23    | 105   | 173   | 495   | 60    | 124   | 84    | 65    |
| Cyclotella, . . . . .         | 0     | 1     | 0     | 2     | 0     | 100   | 140   | 468   | 60    | 100   | 40    | 28    |
| Diatoma, . . . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 20    | 0     | 0     | 0     | 0     |
| Synedra, . . . . .            | 0     | 0     | 0     | 1     | 14    | 4     | 32    | 2     | 0     | 24    | 44    | 37    |
| Tabellaria, . . . . .         | 0     | 0     | 0     | pr.   | 9     | 1     | 1     | 5     | 0     | 0     | 0     | 0     |
| Cyanophyceæ, Microcystis, .   | 0     | 0     | 0     | 0     | 0     | 2     | 6     | 0     | 0     | 0     | 0     | 0     |
| Algae, . . . . .              | 0     | 0     | 0     | 0     | 0     | 22    | 0     | 39    | 0     | 13    | 6     | 9     |
| Gleocapsa, . . . . .          | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 17    | 0     | 0     | 0     | 0     |
| Protooccus, . . . . .         | 0     | 0     | 0     | 0     | 0     | 22    | 0     | 20    | 0     | 4     | 6     | 0     |
| Raphidium, . . . . .          | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 9     | 0     | 9     |
| Fungi, Crenothrix, . . . . .  | 0     | 0     | 2     | 2     | 1     | 0     | 2     | 0     | 0     | 0     | 0     | 0     |
| ANIMALS.                      |       |       |       |       |       |       |       |       |       |       |       |       |
| Rhizopoda, Actinophrys, . .   | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 1     | 0     |
| Infusoria, . . . . .          | 0     | 0     | pr.   | 9     | 5     | 0     | 0     | 0     | 0     | 1     | 0     | 1     |
| Dinobryon cascs, . . . . .    | 0     | 0     | 0     | 9     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Tracholomonas, . . . . .      | 0     | 0     | pr.   | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     |
| Vorticella, . . . . .         | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 1     | 0     | 0     |
| Vorticella stems, . . . . .   | 0     | 0     | 0     | pr.   | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Vermes, . . . . .             | 7     | 0     | 0     | 0     | 0     | 1     | 2     | 0     | 0     | 0     | 0     | 0     |
| Anura, . . . . .              | 4     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     |
| Rotatorian ova, . . . . .     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Rotifer, . . . . .            | 1     | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     |
| Miscellaneous, Zoöglæa, . . . | 0     | 0     | 0     | 0     | 5     | 0     | 4     | 0     | 8     | 60    | 20    | 7     |
| TOTAL, . . . . .              | 7     | 1     | 2     | 14    | 35    | 130   | 187   | 534   | 68    | 198   | 111   | 82    |



BOSTON.

**SUDBURY RIVER SUPPLY.**—*Chemical Examination of Water from Reservoir No. 4, Ashland, collected Twenty Feet beneath the Surface.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1570    | 1895.<br>July 1     | V. slight.  | Slight.   | 0.95   | 3.80                            | 1.85                 | .0042    | .0204       | .0186      | .0018           | .80       | .0070          | .0001     | .8800            | 0.9       |

Odor, distinctly vegetable and sweetish. Iron, .0070.

*Microscopical Examination.*

Diatomaceæ, *Cyclotella*, 136; *Synedra*, 10; *Tabellaria*, 1. Algæ, *Protococcus*, 18; *Raphidium*, 5. Infusoria, *Trachelomonas*, 1. Total, 171.

**SUDBURY RIVER SUPPLY.**—*Chemical Examination of Water from Reservoir No. 4, Ashland, collected near the Bottom.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 371     | 1895.<br>July 1     | V. slight.  | V. slight. | 0.90   | 3.75                            | 1.70                 | .0030    | .0192       | .0176      | .0016           | .81       | .0050          | .0001     | .7955            | 0.9       |
| 147     | Aug. 1              | V. slight.  | V. slight. | 0.70   | 4.40                            | 1.45                 | .0010    | .0202       | .0190      | .0012           | .80       | .0070          | .0000     | .8393            | 1.3       |

Odor of the first sample, distinctly vegetable and sweetish; of the last, faintly vegetable. Iron in first sample, .0150; in the last, not determined.

*Microscopical Examination.*

No. 14571. Diatomaceæ, *Cyclotella*, 48; *Synedra*, 1. Algæ, *Protococcus*, 1. Total, 50.

No. 14747. Diatomaceæ, *Cyclotella*, 36; *Diatoma*, 4; *Synedra*, 14; *Tabellaria*, 1. Total, 55.

BOSTON.

DBURY RIVER SUPPLY.—*Chemical Examination of Water from Reservoir No. 2, Framingham.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE.          |                    |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. |           |
|---------------------|----------------------|--------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                     | Turbidity.           | Sediment.          | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. | Oxygen Consumed. | Hardness. |
|                     |                      |                    |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.               |                      |                    |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| Jan. 1              | V. slight.           | V. slight.         | 1.30   | 5.15                            | 2.35                 | .0010    | .0228       | .0210      | .0028           | .38       | .0070          | .0000     | 1.2320           | 1.7       |
| Feb. 4              | V. slight.           | V. slight.         | 1.10   | 5.15                            | 2.05                 | .0004    | .0196       | .0180      | .0036           | .38       | .0150          | .0000     | 1.0665           | 1.3       |
| Mar. 4              | V. slight.           | V. slight.         | 0.90   | 5.10                            | 1.85                 | .0028    | .0184       | .0146      | .0038           | .39       | .0280          | .0001     | .8008            | 1.4       |
| Apr. 1              | V. slight.           | V. slight.         | 0.70   | 3.70                            | 1.75                 | .0010    | .0160       | .0148      | .0012           | .28       | .0100          | .0001     | .6352            | 0.9       |
| May 1               | Slight.              | Slight.            | 1.00   | 4.10                            | 1.95                 | .0014    | .0198       | .0178      | .0020           | .32       | .0100          | .0001     | .8123            | 1.1       |
| June 3              | Decided.             | Cons.,<br>brown.   | 1.05   | 4.10                            | 1.75                 | .0004    | .0262       | .0242      | .0020           | .31       | .0040          | .0004     | .9500            | 1.3       |
| July 1              | Distinct.            | Slight,<br>yellow. | 1.30   | 4.60                            | 1.50                 | .0054    | .0284       | .0264      | .0020           | .30       | .0030          | .0001     | 1.0167           | 1.1       |
| Aug. 1              | Distinct,<br>clayey. | Slight.            | 0.70   | 4.55                            | 1.90                 | .0010    | .0246       | .0210      | .0036           | .40       | .0050          | .0001     | .7392            | 1.3       |
| Sept. 3             | Slight.              | Cons.              | 0.85   | 4.50                            | 1.90                 | .0004    | .0278       | .0230      | .0048           | .40       | .0050          | .0002     | .7777            | 1.1       |
| Oct. 1              | Distinct,<br>clayey. | Slight,<br>earthy. | 0.53   | 3.90                            | 1.85                 | .0002    | .0266       | .0224      | .0042           | .36       | .0030          | .0000     | .6240            | 1.3       |
| Nov. 4              | V. slight.           | V. slight.         | 1.70   | 6.45                            | 3.35                 | .0036    | .0368       | .0286      | .0082           | .36       | .0100          | .0002     | 2.0670           | 1.3       |
| Dec. 2              | Distinct.            | Slight.            | 1.20   | 4.55                            | 2.45                 | .0010    | .0248       | .0238      | .0010           | .24       | .0080          | .0000     | 1.0826           | 0.8       |
|                     |                      |                    |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| .....               |                      |                    | 1.03   | 4.65                            | 2.05                 | .0015    | .0244       | .0211      | .0033           | .34       | .0090          | .0001     | .9837            | 1.2       |

*Averages by Years.*

|       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| 1887* | - | - | 1.09 | 4.94 | 1.87 | .0015 | .0335 | -     | -     | .34 | .0048 | -     | -     | -   |
| 1888  | - | - | 1.08 | 4.63 | 2.01 | .0005 | .0300 | -     | -     | .30 | .0102 | .0001 | -     | -   |
| 1889  | - | - | 1.04 | 3.42 | 1.26 | .0015 | .0296 | .0252 | .0044 | .29 | .0075 | .0002 | -     | -   |
| 1890  | - | - | 0.77 | 4.58 | 1.83 | .0010 | .0235 | .0191 | .0044 | .28 | .0128 | .0001 | -     | 1.7 |
| 1891  | - | - | 0.72 | 4.02 | 1.68 | .0004 | .0230 | .0194 | .0036 | .24 | .0105 | .0001 | -     | 1.0 |
| 1892  | - | - | 0.89 | 4.35 | 1.92 | .0004 | .0231 | .0192 | .0039 | .29 | .0082 | .0001 | -     | 1.3 |
| 1893  | - | - | 0.98 | 4.28 | 1.86 | .0010 | .0219 | .0190 | .0029 | .31 | .0054 | .0001 | .8120 | 1.2 |
| 1894  | - | - | 1.12 | 4.36 | 2.05 | .0008 | .0216 | .0193 | .0023 | .33 | .0058 | .0000 | .9268 | 1.3 |
| 1895  | - | - | 1.03 | 4.65 | 2.05 | .0015 | .0244 | .0211 | .0033 | .34 | .0090 | .0001 | .9837 | 1.2 |

\* June to December.

NOTE to analyses of 1895: Odor, vegetable.—The samples were collected from the reservoir, the gate-house, at a depth of 8 feet beneath the surface. For monthly record of height of water in reservoir, see table at end of Boston analyses.

**BOSTON.****SUDBURY RIVER SUPPLY.—Microscopical Examination of Water from Reservoir No. 2, Framingham.**

[Number of organisms per cubic centimeter]

|                                 | 1895.     |          |            |           |           |            |            |            |            |            |           |            |
|---------------------------------|-----------|----------|------------|-----------|-----------|------------|------------|------------|------------|------------|-----------|------------|
|                                 | Jan.      | Feb.     | Mar.       | Apr.      | May.      | June.      | July.      | Aug.       | Sept.      | Oct.       | Nov.      | Dec.       |
| Day of examination, . . . .     | 2         | 5        | 6          | 3         | 1         | 4          | 2          | 2          | 4          | 2          | 6         | 3          |
| Number of sample, . . . .       | 13568     | 13744    | 13912      | 14065     | 14223     | 14405      | 14560      | 14749      | 14953      | 15287      | 15467     | 15652      |
| <b>PLANTS.</b>                  |           |          |            |           |           |            |            |            |            |            |           |            |
| Diatomaceæ, . . . .             | 16        | 5        | 3          | 11        | 60        | 156        | 469        | 374        | 535        | 236        | 6         | 18         |
| Cyclotella, . . . .             | 0         | 0        | 0          | 0         | 0         | 67         | 456        | 372        | 528        | 216        | 0         | 0          |
| Melosira, . . . .               | 3         | 0        | 0          | 1         | 2         | 0          | 1          | 0          | 0          | 5          | 0         | 0          |
| Navicula, . . . .               | 0         | 0        | 0          | pr.       | 2         | 10         | 3          | 0          | 2          | 2          | 0         | 0          |
| Pinnularia, . . . .             | 0         | 0        | 0          | 0         | 0         | 0          | 1          | 0          | 2          | 4          | 0         | 0          |
| Synedra, . . . .                | 4         | 4        | 3          | 3         | 48        | 74         | 5          | 2          | 3          | 9          | 5         | 12         |
| Tabellaria, . . . .             | 9         | 1        | 0          | 7         | 8         | 5          | 3          | 0          | 0          | 0          | 1         | 6          |
| Cyanophyceæ, . . . .            | 0         | 0        | 0          | 0         | 0         | 1          | 22         | 3          | 0          | 3          | 0         | 0          |
| Merismopedia, . . . .           | 0         | 0        | 0          | 0         | 0         | 0          | 22         | 0          | 0          | 0          | 0         | 0          |
| Microcystis, . . . .            | 0         | 0        | 0          | 0         | 0         | 1          | 0          | 3          | 0          | 3          | 0         | 0          |
| Algæ, . . . .                   | 0         | 0        | 1          | 0         | 4         | 47         | 148        | 88         | 88         | 114        | 0         | 0          |
| Gloëocapsa, . . . .             | 0         | 0        | 0          | 0         | 0         | 0          | 84         | 2          | 0          | 0          | 0         | 0          |
| Protooccus, . . . .             | 0         | 0        | 1          | 0         | 3         | 18         | 61         | 27         | 55         | 108        | 0         | 0          |
| Raphidium, . . . .              | 0         | 0        | 0          | 0         | 0         | 10         | 0          | 20         | 28         | 6          | 0         | 0          |
| Scenedesmus, . . . .            | 0         | 0        | 0          | 0         | 1         | 19         | 3          | 1          | 5          | 0          | 0         | 0          |
| Staurogenia, . . . .            | 0         | 0        | 0          | 0         | 0         | 0          | 0          | 38         | 0          | 0          | 0         | 0          |
| Fungi, Crenothrix, . . . .      | 0         | 2        | 4          | 5         | 9         | 0          | 0          | 5          | 1          | 0          | 28        | 24         |
| <b>ANIMALS.</b>                 |           |          |            |           |           |            |            |            |            |            |           |            |
| Infusoria, . . . .              | 1         | 0        | 0          | 5         | 6         | 0          | 0          | 0          | 0          | 1          | 2         | 2          |
| Codonella, . . . .              | 0         | 0        | 0          | 0         | 0         | 0          | 0          | 0          | 0          | 0          | 2         | 0          |
| Dinobryon casca, . . . .        | 0         | 0        | 0          | 2         | 3         | 0          | 0          | 0          | 0          | 0          | 0         | 0          |
| Euglena, . . . .                | 0         | 0        | 0          | 2         | 0         | 0          | 0          | 0          | 0          | 0          | 0         | 0          |
| Peridinium, . . . .             | 1         | 0        | 0          | 1         | 3         | 0          | 0          | 0          | 0          | 0          | 0         | 0          |
| Trachelomonas, . . . .          | 0         | 0        | 0          | 0         | 0         | 0          | 0          | 0          | 0          | 1          | 0         | 3          |
| Miscellaneous, Zoöglæa, . . . . | 0         | 0        | 154        | 16        | 0         | 0          | 0          | 0          | 292        | 160        | 40        | 60         |
| <b>TOTAL, . . . .</b>           | <b>17</b> | <b>7</b> | <b>162</b> | <b>37</b> | <b>79</b> | <b>204</b> | <b>639</b> | <b>470</b> | <b>916</b> | <b>514</b> | <b>70</b> | <b>104</b> |

BOSTON.

WILMINGTON RIVER SUPPLY.—*Chemical Examination of Water from Walker's Brook, Marlborough.*

[Parts per 100,000.]

| Date of Collection. |                   | APPEARANCE.     |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------------------|-------------------|-----------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|                     |                   | Turbidity.      | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|                     |                   |                 |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.               |                   |                 |           |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| Jan. 2              | Slight.           | Cons.           | 0.20      | 13.65  | 3.00                    | .0240             | .0144    | .0112       | .0032      | 1.98       | .2900     | .0034       | .2117     | 5.6              |           |
| Feb. 4              | Slight.           | Cons.           | 0.50      | 12.90  | 3.05                    | .0380             | .0224    | .0200       | .0024      | 1.81       | .2000     | .0018       | .5056     | 4.6              |           |
| Mar. 4              | Distinct, milky.  | Cons., gray.    | 0.70      | 12.80  | 3.20                    | .0784             | .0286    | .0234       | .0052      | 1.75       | .1900     | .0023       | .7892     | 4.2              |           |
| Apr. 1              | Slight.           | Slight.         | 0.55      | 13.35  | 4.95                    | .0800             | .0200    | .0150       | .0050      | 1.71       | .2500     | .0025       | .5221     | 4.0              |           |
| May 1               | Slight.           | Cons.           | 0.70      | 13.90  | 4.70                    | .0310             | .0440    | .0290       | .0150      | 1.88       | .2400     | .0020       | .6660     | 4.6              |           |
| June 3              | Distinct, milky.  | Slight.         | 0.55      | 16.10  | 4.90                    | .0116             | .0292    | .0264       | .0028      | 2.20       | .1360     | .0100       | .5472     | 5.9              |           |
| July 1              | Distinct, milky.  | Slight.         | 0.65      | 17.10  | 2.35                    | .0240             | .0248    | .0228       | .0020      | 2.46       | .0830     | .0050       | .6038     | 5.9              |           |
| Aug. 1              | Distinct, milky.  | Slight.         | 0.55      | 16.40  | 2.00                    | .0080             | .0312    | .0256       | .0056      | 2.30       | .0830     | .0030       | .6240     | 5.9              |           |
| Sept. 2             | Slight.           | Slight.         | 0.18      | 14.80  | 3.40                    | .0000             | .0152    | .0142       | .0010      | 2.20       | .1000     | .0048       | .2680     | 5.3              |           |
| Oct. 1              | Slight, milky.    | Slight.         | 0.28      | 15.25  | 3.00                    | .0128             | .0144    | .0124       | .0020      | 2.25       | .1200     | .0040       | .2668     | 4.9              |           |
| Nov. 4              | Distinct, clayey. | Cons., earthy.  | 1.10      | 17.00  | 6.15                    | .0212             | .0386    | .0338       | .0048      | 2.10       | .1800     | .0015       | 1.1583    | 5.9              |           |
| Dec. 3              | Distinct, clayey. | Slight, earthy. | 0.90      | 13.30  | 4.80                    | .0220             | .0242    | .0224       | .0018      | 1.82       | .2500     | .0017       | .8073     | 4.4              |           |
| .....               | .....             | .....           | 0.57      | 14.71  | 3.79                    | .0292             | .0256    | .0214       | .0042      | 2.04       | .1768     | .0035       | .5808     | 5.1              |           |

## Averages by Years.

|      |   |   |      |       |      |       |       |       |       |      |       |       |       |     |
|------|---|---|------|-------|------|-------|-------|-------|-------|------|-------|-------|-------|-----|
| 1892 | - | - | 0.49 | 16.84 | 4.35 | .0307 | .0274 | .0225 | .0048 | 2.58 | .2975 | .0037 | -     | 5.7 |
| 1893 | - | - | 0.38 | 14.05 | 3.94 | .0337 | .0257 | .0180 | .0077 | 1.96 | .1878 | .0020 | .3927 | 5.2 |
| 1894 | - | - | 0.46 | 14.14 | 3.62 | .0371 | .0217 | .0171 | .0046 | 2.08 | .1888 | .0018 | .4701 | 4.9 |
| 1895 | - | - | 0.57 | 14.71 | 3.79 | .0292 | .0256 | .0214 | .0042 | 2.04 | .1768 | .0035 | .5808 | 5.1 |

As to analyses of 1895: Odor, distinctly vegetable or musty. The samples were collected from the brook, at the first road bridge below Maple Street, about a mile south of the centre of the city of Waltham.

## BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Stony Brook, at Head of Reservoir No. 3, Southborough.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.        | Sediment.       | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                   |                 |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.   |                     |                   |                 |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 13569   | Jan. 1              | Slight.           | Cons.           | 0.90   | 7.10                    | 2.40              | .0066    | .0314       | .0286      | .0028      | .64       | .0320       | .0002     | 0.7007           | 2.6       |
| 13745   | Feb. 4              | Slight.           | Cons.           | 1.10   | 6.25                    | 2.00              | .0054    | .0220       | .0196      | .0024      | .51       | .0300       | .0001     | 1.1060           | 1.9       |
| 13913   | Mar. 4              | Slight.           | Slight.         | 0.80   | 5.55                    | 1.85              | .0174    | .0252       | .0234      | .0018      | .45       | .0380       | .0002     | 0.7685           | 1.6       |
| 14066   | Apr. 1              | V. slight.        | Slight.         | 0.80   | 4.30                    | 1.70              | .0002    | .0234       | .0212      | .0022      | .35       | .0200       | .0003     | 0.7469           | 1.4       |
| 14224   | May 1               | Slight.           | Cons.           | 1.30   | 5.60                    | 2.65              | .0012    | .0274       | .0252      | .0022      | .42       | .0220       | .0003     | 1.1550           | 1.8       |
| 14406   | June 3              | Decided, brown.   | Cons., brown.   | 1.80   | 7.05                    | 3.05              | .0114    | .0430       | .0378      | .0052      | .42       | .0120       | .0008     | 1.0000           | 1.9       |
| 14561   | July 1              | Distinct.         | Slight, brown.  | 1.25   | 7.95                    | 2.30              | .0014    | .0368       | .0328      | .0040      | .70       | .0100       | .0002     | 0.9298           | 2.2       |
| 14750   | Aug. 1              | Decided, green.   | Cons., brown.   | 0.70   | 6.00                    | 1.80              | .0006    | .0376       | .0338      | .0038      | .40       | .0050       | .0000     | 0.7199           | 2.1       |
| 14954   | Sept. 3             | Distinct, milky.  | Slight.         | 0.80   | 7.00                    | 2.05              | .0010    | .0242       | .0226      | .0016      | .54       | .0050       | .0003     | 0.6314           | 2.1       |
| 15288   | Oct. 1              | Decided, clayey.  | Cons., earthy.  | 0.48   | 8.75                    | 2.15              | .0028    | .0406       | .0218      | .0188      | .52       | .0150       | .0004     | 0.4430           | 2.6       |
| 15468   | Nov. 4              | Distinct, clayey. | Slight, earthy. | 1.60   | 7.55                    | 3.40              | .0005    | .0400       | .0335      | .0062      | .48       | .0080       | .0002     | 1.7004           | 2.2       |
| 15653   | Dec. 2              | Distinct, clayey. | Slight          | 0.98   | 5.50                    | 2.20              | .0008    | .0202       | .0186      | .0016      | .39       | .0380       | .0002     | 0.9360           | 1.7       |
| Av.     | .....               | .....             | .....           | 1.03   | 6.55                    | 2.30              | .0041    | .0310       | .0266      | .0044      | .49       | .0196       | .0003     | 0.9781           | 2.0       |

*Averages by Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |        |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|--------|-----|
| - | 1887* | - | - | 0.97 | 7.74 | 2.36 | .0029 | .0355 | -     | -     | .74 | .0152 | -     | -      | -   |
| - | 1888  | - | - | 1.16 | 6.25 | 2.17 | .0039 | .0312 | -     | -     | .51 | .0303 | .0004 | -      | -   |
| - | 1889  | - | - | 1.11 | 5.04 | 1.76 | .0061 | .0308 | .0280 | .0028 | .50 | .0275 | .0005 | -      | -   |
| - | 1890  | - | - | 0.72 | 7.31 | 2.12 | .0033 | .0257 | .0225 | .0032 | .56 | .0262 | .0003 | -      | 2.4 |
| - | 1891  | - | - | 0.86 | 6.15 | 2.24 | .0047 | .0291 | .0256 | .0035 | .59 | .0226 | .0003 | -      | 2.0 |
| - | 1892  | - | - | 0.96 | 6.19 | 2.35 | .0015 | .0291 | .0252 | .0039 | .49 | .0202 | .0002 | -      | 1.9 |
| - | 1893  | - | - | 0.95 | 6.03 | 2.27 | .0027 | .0273 | .0237 | .0036 | .50 | .0127 | .0002 | .8254  | 2.0 |
| - | 1894  | - | - | 1.32 | 6.41 | 2.64 | .0023 | .0302 | .0249 | .0053 | .49 | .0151 | .0001 | 1.0533 | 2.0 |
| - | 1895  | - | - | 1.03 | 6.55 | 2.30 | .0041 | .0310 | .0266 | .0044 | .49 | .0196 | .0003 | .9781  | 2.0 |

\* June to December.

NOTE to analyses of 1895: Odor, generally distinctly vegetable, occasionally mouldy or unpleasant.

— The samples were collected from the brook, about 50 feet below the first road above Reservoir No. 3, at a depth of 1 foot beneath the surface.

*Microscopical Examination.*

The average number of organisms per cubic centimeter found in these samples was 203.

BOSTON.

**SUDBURY RIVER SUPPLY.—Chemical Examination of Water from Reservoir  
No. 3, Framingham.**

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                    |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |           |                 | Chlorine. | NITROGEN<br>AS |          | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|--------------------|--------|---------------------------------|----------------------|----------|-------------|-----------|-----------------|-----------|----------------|----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment.          | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |           |                 |           | Nitrate.       | Nitrite. |                  |           |
|         |                     |                     |                    |        |                                 |                      |          | Total.      | Dissolved | Sus-<br>pended. |           |                |          |                  |           |
| 13570   | 1895.<br>Jan. 1     | V. slight.          | Slight.            | 1.10   | 5.95                            | 2.60                 | .0034    | .0258       | .0240     | .0018           | .48       | .0130          | .0001    | .9317            | 2.2       |
| 13746   | Feb. 4              | V. slight.          | V. slight.         | 1.00   | 5.80                            | 1.95                 | .0048    | .0228       | .0194     | .0032           | .50       | .0280          | .0001    | 1.0665           | 1.9       |
| 13914   | Mar. 4              | V. slight.          | V. slight.         | 0.88   | 6.20                            | 2.25                 | .0056    | .0200       | .0180     | .0020           | .49       | .0270          | .0001    | .8470            | 1.8       |
| 14067   | Apr. 1              | Slight.             | Slight.            | 0.75   | 4.45                            | 2.10                 | .0050    | .0194       | .0184     | .0010           | .34       | .0240          | .0003    | .6506            | 1.4       |
| 14225   | May 1               | Slight.             | Cons.              | 1.00   | 4.60                            | 1.95                 | .0014    | .0228       | .0188     | .0040           | .37       | .0230          | .0002    | .7969            | 1.4       |
| 14407   | June 3              | Distinct.           | Slight,<br>brown.  | 0.90   | 4.95                            | 2.35                 | .0028    | .0250       | .0232     | .0018           | .39       | .0130          | .0002    | .7904            | 1.7       |
| 14562   | July 1              | Distinct,<br>green. | Slight,<br>yellow. | 0.80   | 4.85                            | 1.65                 | .0000    | .0304       | .0210     | .0094           | .38       | .0000          | .0001    | .7955            | 1.7       |
| 14751   | Aug. 1              | Decided,<br>green.  | Cons.,<br>brown.   | 0.65   | 5.85                            | 2.10                 | .0004    | .0302       | .0256     | .0046           | .31       | .0050          | .0000    | .7956            | 2.2       |
| 14935   | Sept. 3             | Decided,<br>green.  | Cons.,<br>yellow.  | 0.60   | 5.45                            | 2.35                 | .0000    | .0308       | .0230     | .0078           | .45       | .0030          | .0001    | .6737            | 1.8       |
| 15289   | Oct. 1              | Decided,<br>green.  | Slight,<br>earthy. | 0.45   | 5.10                            | 2.25                 | .0020    | .0410       | .0308     | .0102           | .42       | .0030          | .0000    | .6708            | 1.8       |
| 15460   | Nov. 4              | Distinct.           | Slight,<br>earthy. | 1.05   | 6.20                            | 2.65                 | .0042    | .0326       | .0304     | .0022           | .46       | .0220          | .0002    | 1.0920           | 1.9       |
| 15654   | Dec. 2              | Decided,<br>clayey. | Slight.            | 1.15   | 5.80                            | 2.40                 | .0024    | .0268       | .0246     | .0022           | .36       | .0200          | .0001    | 1.0179           | 1.7       |
| Av.     | .....               | .....               | .....              | 0.86   | 5.43                            | 2.22                 | .0027    | .0273       | .0231     | .0042           | .41       | .0151          | .0001    | .8440            | 1.8       |

## Averages by Years.

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 0.91 | 5.48 | 2.02 | .0073 | .0318 | -     | -     | .43 | .0170 | -     | -     | -   |
| - | 1888  | - | - | 0.98 | 4.98 | 1.79 | .0038 | .0288 | -     | -     | .40 | .0218 | .0003 | -     | -   |
| - | 1889  | - | - | 0.84 | 4.39 | 1.50 | .0042 | .0306 | .0254 | .0052 | .42 | .0182 | .0003 | -     | -   |
| - | 1890  | - | - | 0.62 | 5.40 | 1.84 | .0020 | .0238 | .0197 | .0041 | .40 | .0229 | .0002 | -     | 2.0 |
| - | 1891  | - | - | 0.60 | 4.75 | 1.66 | .0032 | .0242 | .0200 | .0042 | .38 | .0190 | .0002 | -     | 1.7 |
| - | 1892  | - | - | 0.72 | 5.17 | 1.97 | .0024 | .0254 | .0219 | .0035 | .40 | .0211 | .0001 | -     | 1.8 |
| - | 1893  | - | - | 0.90 | 4.97 | 2.10 | .0028 | .0259 | .0207 | .0052 | .37 | .0100 | .0001 | .7681 | 1.7 |
| - | 1894  | - | - | 0.97 | 5.48 | 2.20 | .0018 | .0265 | .0231 | .0034 | .41 | .0105 | .0002 | .8092 | 1.9 |
| - | 1895  | - | - | 0.86 | 5.43 | 2.22 | .0027 | .0273 | .0231 | .0042 | .41 | .0151 | .0001 | .8440 | 1.8 |

\* June to December.

**NOTE to analyses of 1895:** Odor, vegetable and occasionally unpleasant, becoming somewhat stronger on boiling. — The samples were collected from the reservoir, near the gate-house, at a depth of 8 feet beneath the surface. For monthly record of height of water in this reservoir, see table at end of Boston analyses.

## BOSTON.

SUDBURY RIVER SUPPLY.—*Microscopical Examination of Water from Reservoir No. 3, Framingham.*

[Number of organisms per cubic centimeter.]

|                                   | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|-----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                   | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . . .     | 2     | 5     | 6     | 3     | 2     | 5     | 2     | 3     | 5     | 2     | 6     | 3     |
| Number of sample, . . . . .       | 13570 | 13746 | 13914 | 14067 | 14225 | 14407 | 14562 | 14751 | 14955 | 15289 | 15469 | 15654 |
| <b>PLANTS.</b>                    |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . . .             | 128   | 4     | 1     | 7     | 408   | 624   | 431   | 539   | 252   | 1,089 | 671   | 189   |
| Asterionella, . . . . .           | 114   | 0     | 0     | 3     | 180   | 79    | 1     | 10    | 4     | 660   | 468   | 140   |
| Cyclotella, . . . . .             | 8     | 0     | 0     | 1     | 5     | 47    | 312   | 308   | 72    | 72    | 2     | 3     |
| Diatoma, . . . . .                | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 6     | 0     | 0     | 0     | 2     |
| Fragilaria, . . . . .             | 0     | 0     | 0     | 0     | 5     | 0     | 0     | 25    | 0     | 0     | 0     | 0     |
| Melosira, . . . . .               | 0     | 0     | 0     | 0     | 10    | 126   | 0     | 8     | 4     | 0     | 10    | 2     |
| Meridion, . . . . .               | 0     | 1     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 4     |
| Stephanodiscus, . . . . .         | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 7     | 0     |
| Synedra, . . . . .                | 0     | 0     | 0     | 2     | 116   | 20    | 2     | 2     | 0     | 33    | 0     | 5     |
| Tabellaria, . . . . .             | 6     | 2     | 1     | 0     | 112   | 352   | 116   | 180   | 172   | 324   | 184   | 13    |
| Cyanophyceæ, . . . . .            | 0     | 1     | 1     | 0     | 0     | 3     | 84    | 87    | 303   | 78    | 32    | 0     |
| Anabæna, . . . . .                | 0     | 0     | 0     | 0     | 0     | 0     | 7     | 50    | 150   | 13    | 0     | 0     |
| Clostrorhynchus, . . . . .        | 0     | 0     | 0     | 0     | 0     | 0     | 29    | 1     | 0     | 7     | 2     | 0     |
| Coclopharum, . . . . .            | 0     | 1     | 1     | 0     | 0     | 0     | 0     | 32    | 150   | 55    | 30    | 0     |
| Microcystis, . . . . .            | 0     | 0     | 0     | 0     | 0     | 3     | 28    | 4     | 3     | 3     | 0     | 0     |
| Algæ, . . . . .                   | 0     | 0     | 0     | 0     | 1     | 45    | 469   | 116   | 10    | 55    | 124   | 4     |
| Chlorococcus, . . . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 8     | 3     | 6     | 0     |
| Gloeocapsa, . . . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 5     | 1     | 0     | 0     | 0     |
| Pediastrum, . . . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 2     | 0     | 1     | 2     | 0     |
| Protococcus, . . . . .            | 0     | 0     | 0     | 0     | 1     | 24    | 464   | 32    | 0     | 33    | 0     | 0     |
| Raphidium, . . . . .              | 0     | 0     | 0     | 0     | 0     | 12    | 0     | 72    | 0     | 6     | 116   | 4     |
| Scenedesmus, . . . . .            | 0     | 0     | 0     | 0     | 0     | 8     | 0     | 0     | 0     | 0     | 0     | 0     |
| Selenastrum, . . . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 10    | 0     | 0     |
| Staurostrum, . . . . .            | 0     | 0     | 0     | 0     | 0     | 1     | 1     | 5     | 1     | 2     | 0     | 0     |
| Fungi, Crenothrix, . . . . .      | 0     | 2     | 3     | 4     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 4     |
| <b>ANIMALS.</b>                   |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . . . .              | 1     | 0     | 0     | 0     | 0     | 2     | 1     | 15    | 7     | 15    | 0     | 0     |
| Mallomonas, . . . . .             | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 1     | 2     | 0     | 0     |
| Trachelomonas, . . . . .          | 1     | 0     | 0     | 0     | 0     | 0     | 1     | 14    | 6     | 12    | 0     | 0     |
| Vorticella, . . . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 1     | 0     | 0     |
| Miscellaneous, Zoöglæa, . . . . . | 0     | 0     | 11    | 9     | 0     | 116   | 0     | 0     | 0     | 0     | 0     | 100   |
| TOTAL, . . . . .                  | 129   | 7     | 16    | 20    | 409   | 790   | 965   | 757   | 572   | 1,237 | 827   | 277   |

## BOSTON.

WATUATE SUPPLY. — *Chemical Examination of Water from Lake Cochituate, in Wayland.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------------------|-------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|                     |             |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.               |             |                   |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 1 Jan. 1            | Slight.     | Cons.             | .25    | 4.85                            | 1.70                 | .0032    | .0196       | .0160      | .0036           | .52       | .0070          | .0000     | .3542            | 2.2       |
| 7 Feb. 4            | V. slight.  | Slight.           | .28    | 5.40                            | 1.30                 | .0024    | .0170       | .0146      | .0024           | .56       | .0100          | .0000     | .4187            | 2.1       |
| 5 Mar. 4            | V. slight.  | Cons.             | .30    | 5.85                            | 1.70                 | .0006    | .0154       | .0140      | .0014           | .56       | .0220          | .0000     | .4697            | 2.3       |
| 8 Apr. 1            | V. slight.  | Slight.           | .30    | 5.20                            | 1.95                 | .0010    | .0192       | .0160      | .0032           | .49       | .0220          | .0002     | .4350            | 1.9       |
| 6 May 1             | Slight.     | Slight.           | .27    | 4.90                            | 1.55                 | .0014    | .0160       | .0136      | .0024           | .48       | .0200          | .0002     | .4196            | 2.1       |
| 6 June 3            | Slight.     | Slight.           | .27    | 5.10                            | 2.30                 | .0026    | .0168       | .0148      | .0020           | .48       | .0180          | .0003     | .4636            | 1.8       |
| 3 July 1            | Distinct.   | Slight.           | .25    | 4.80                            | 1.60                 | .0014    | .0184       | .0154      | .0030           | .50       | .0050          | .0004     | .4716            | 1.7       |
| 2 Aug. 1            | Slight.     | Slight.           | .25    | 5.40                            | 1.55                 | .0002    | .0166       | .0150      | .0016           | .50       | .0070          | .0002     | .4680            | 2.6       |
| 6 Sept. 3           | Slight.     | Slight.           | .18    | 5.20                            | 1.50                 | .0002    | .0184       | .0158      | .0026           | .55       | .0030          | .0003     | .4143            | 2.1       |
| 0 Oct. 1            | Slight.     | Slight.           | .20    | 5.00                            | 1.50                 | .0010    | .0198       | .0184      | .0014           | .52       | .0030          | .0001     | .3627            | 1.7       |
| 8 Nov. 6            | Decided.    | Slight,<br>green. | .22    | 4.70                            | 1.65                 | .0010    | .0176       | .0140      | .0036           | .50       | .0090          | .0001     | .3682            | 2.2       |
| 5 Dec. 2            | Decided.    | Slight.           | .22    | 5.10                            | 1.85                 | .0034    | .0182       | .0158      | .0024           | .52       | .0080          | .0000     | .4040            | 1.9       |
| .....               | .....       | .....             | .25    | 5.08                            | 1.68                 | .0015    | .0178       | .0153      | .0025           | .51       | .0112          | .0001     | .4208            | 2.1       |

## Averages by Years.

|       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| 1887* | - | - | .21 | 5.08 | 1.38 | .0017 | .0186 | -     | -     | .44 | .0096 | -     | -     | -   |
| 1888  | - | - | .19 | 4.90 | 1.24 | .0033 | .0217 | -     | -     | .43 | .0127 | .0003 | -     | -   |
| 1889  | - | - | .33 | 5.08 | 1.62 | .0025 | .0210 | .0177 | .0033 | .46 | .0208 | .0003 | -     | -   |
| 1890  | - | - | .21 | 4.74 | 1.03 | .0016 | .0184 | .0149 | .0035 | .49 | .0206 | .0003 | -     | 2.4 |
| 1891  | - | - | .24 | 4.66 | 1.44 | .0017 | .0182 | .0145 | .0037 | .42 | .0212 | .0002 | -     | 1.8 |
| 1892  | - | - | .15 | 4.61 | 1.35 | .0018 | .0168 | .0133 | .0035 | .48 | .0152 | .0001 | -     | 2.0 |
| 1893  | - | - | .21 | 4.64 | 1.58 | .0015 | .0168 | .0138 | .0030 | .46 | .0098 | .0002 | .3925 | 2.0 |
| 1894  | - | - | .20 | 4.76 | 1.59 | .0008 | .0163 | .0137 | .0026 | .51 | .0070 | .0001 | .3699 | 2.1 |
| 1895  | - | - | .25 | 5.08 | 1.68 | .0015 | .0178 | .0153 | .0025 | .51 | .0112 | .0001 | .4208 | 2.1 |

\* June to December.

NOTE to analyses of 1895: Odor, generally vegetable, sometimes none, becoming stronger and somewhat unpleasant on heating. — The samples were collected in the gate-house. For monthly record of  $\delta$  of water in this lake, see table at end of Boston analyses.



BOSTON.

HITUATE WORKS. — *Chemical Examination of Water from a Faucet at the Massachusetts Institute of Technology, Boston.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.               |             |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| Jan. 1              | V. slight.  | V. slight. | 1.10   | 5.15                            | 2.30                 | .0022    | .0246       | .0210      | .0036           | .43       | .0100          | .0000     | .7892            | 1.9       |
| Feb. 5              | V. slight.  | V. slight. | 0.80   | 6.00                            | 1.95                 | .0010    | .0190       | .0176      | .0014           | .46       | .0250          | .0000     | .9085            | 2.1       |
| Mar. 4              | V. slight.  | V. slight. | 0.80   | 5.75                            | 2.20                 | .0016    | .0180       | .0154      | .0026           | .47       | .0230          | .0000     | .7892            | 1.8       |
| Apr. 1              | Slight.     | V. slight. | 0.60   | 5.06                            | 1.90                 | .0010    | .0172       | .0160      | .0012           | .42       | .0300          | .0001     | .5506            | 1.8       |
| May 1               | V. slight.  | Slight.    | 0.60   | 4.55                            | 1.86                 | .0006    | .0174       | .0156      | .0018           | .38       | .0270          | .0001     | .5736            | 1.9       |
| June 3              | Slight.     | Slight.    | 0.60   | 4.85                            | 2.30                 | .0000    | .0176       | .0162      | .0014           | .42       | .0200          | .0001     | .5548            | 1.7       |
| July 1              | Distinct.   | Slight.    | 0.60   | 4.80                            | 2.15                 | .0007    | .0198       | .0180      | .0018           | .39       | .0150          | .0001     | .8038            | 1.6       |
| Aug. 1              | Slight.     | Slight.    | 0.60   | 4.55                            | 1.70                 | .0000    | .0216       | .0198      | .0018           | .36       | .0100          | .0001     | .6474            | 1.8       |
| Sept. 3             | Distinct.   | Slight.    | 0.58   | 4.50                            | 1.95                 | .0000    | .0176       | .0139      | .0038           | .41       | .0080          | .0003     | .5698            | 1.4       |
| Oct. 1              | Slight.     | Slight.    | 0.48   | 4.20                            | 1.56                 | .0002    | .0214       | .0176      | .0038           | .33       | .0050          | .0000     | .5538            | 1.3       |
| Nov. 4              | Slight.     | Slight.    | 0.90   | 5.10                            | 2.55                 | .0000    | .0220       | .0202      | .0018           | .40       | .0120          | .0002     | .8892            | 1.6       |
| Dec. 2              | Slight.     | Slight.    | 0.93   | 4.25                            | 1.80                 | .0008    | .0202       | .0190      | .0012           | .36       | .0200          | .0000     | .8463            | 1.7       |
| .....               | .....       | .....      | 0.72   | 4.90                            | 2.02                 | .0006    | .0197       | .0175      | .0022           | .40       | .0171          | .0001     | .6897            | 1.7       |

*Averages by Years.*

|       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| 1887* | - | - | 0.35 | 4.89 | 1.87 | .0002 | .0225 | -     | -     | .41 | .0094 | -     | -     | -   |
| 1888  | - | - | 0.38 | 4.94 | 1.53 | .0012 | .0215 | -     | -     | .40 | .0183 | .0002 | -     | -   |
| 1889  | - | - | 0.51 | 4.71 | 1.43 | .0005 | .0199 | .0176 | .0023 | .42 | .0272 | .0002 | -     | -   |
| 1890  | - | - | 0.35 | 4.70 | 1.25 | .0003 | .0169 | .0148 | .0021 | .42 | .0241 | .0001 | -     | 2.2 |
| 1891  | - | - | 0.37 | 4.39 | 1.63 | .0005 | .0161 | .0136 | .0025 | .37 | .0227 | .0001 | -     | 1.7 |
| 1892  | - | - | 0.37 | 4.70 | 1.67 | .0007 | .0168 | .0138 | .0030 | .41 | .0210 | .0001 | -     | 1.9 |
| 1893  | - | - | 0.61 | 4.54 | 1.84 | .0010 | .0174 | .0147 | .0027 | .38 | .0143 | .0001 | .5976 | 1.8 |
| 1894  | - | - | 0.69 | 4.14 | 1.83 | .0006 | .0169 | .0150 | .0019 | .41 | .0106 | .0001 | .6295 | 1.7 |
| 1895  | - | - | 0.72 | 4.90 | 2.02 | .0006 | .0197 | .0175 | .0022 | .40 | .0171 | .0001 | .6897 | 1.7 |

\* June to December.

Notes to analyses of 1895: Odor, generally faintly vegetable, rarely none.

## BOSTON.

COCHITUATE WORKS. — *Microscopical Examination of Water from a Faucet at the Massachusetts Institute of Technology, Boston.*

[Number of organisms per cubic centimeter.]

|                                 | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|---------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                 | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . .     | 2     | 5     | 6     | 3     | 2     | 5     | 2     | 3     | 5     | 2     | 6     | 3     |
| Number of sample, . . . .       | 13572 | 13750 | 13916 | 14069 | 14227 | 14409 | 14564 | 14753 | 14957 | 15291 | 15470 | 15655 |
| PLANTS.                         |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . .             | 149   | 24    | 8     | 14    | 113   | 59    | 415   | 104   | 328   | 51    | 479   | 270   |
| Asterionella, . . . .           | 124   | 20    | 6     | 12    | 57    | 2     | 12    | 0     | 0     | 0     | 325   | 200   |
| Cyclotella, . . . .             | 3     | 0     | 0     | 0     | 0     | 1     | 108   | 36    | 56    | 8     | 5     | 2     |
| Fragilaria, . . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 10    | 0     | 0     | 0     |
| Melosira, . . . .               | 6     | 0     | 0     | 0     | 35    | 27    | 1     | 0     | 0     | 0     | 8     | 60    |
| Synedra, . . . .                | 0     | 2     | 1     | 1     | 8     | 5     | 2     | 36    | 6     | 1     | 9     | 0     |
| Tabellaria, . . . .             | 16    | 2     | 1     | 1     | 13    | 24    | 292   | 32    | 256   | 42    | 132   | 8     |
| Cyanophyceæ, . . . .            | 5     | 0     | pr.   | 0     | 0     | 0     | 28    | 3     | 6     | 1     | 11    | 44    |
| Microcystis, . . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 28    | 3     | 6     | 1     | 0     | 0     |
| Oscillaria, . . . .             | 5     | 0     | pr.   | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 11    | 44    |
| Algæ, . . . .                   | 0     | 0     | 0     | 0     | 0     | 95    | 300   | 230   | 12    | 0     | 1     | 2     |
| Protooccus, . . . .             | 0     | 0     | 0     | 0     | 0     | 95    | 300   | 228   | 8     | 0     | 0     | 0     |
| Raphidium, . . . .              | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 4     | 0     | 1     | 2     |
| Fungi, Crenothrix, . . . .      | 0     | 0     | 4     | pr.   | 2     | 0     | 0     | 2     | 7     | 1     | 0     | 0     |
| ANIMALS.                        |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . . .              | pr.   | 4     | 0     | 0     | 5     | 0     | 1     | 4     | 5     | 1     | 1     | 5     |
| Dinobryon cases, . . . .        | 0     | 4     | 0     | 0     | 5     | 0     | 0     | 4     | 5     | 1     | 0     | 0     |
| Mallomonas, . . . .             | pr.   | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 1     |
| Trachelomonas, . . . .          | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 5     |
| Miscellaneous, Zoöglæa, . . . . | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 27    | 0     | 0     | 0     |
| TOTAL, . . . .                  | 154   | 28    | 12    | 14    | 120   | 164   | 744   | 343   | 385   | 54    | 492   | 322   |

BOSTON.

MYSTIC SUPPLY.—*Chemical Examination of Water from Mystic Lake.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE.         |                   |        | RESIDUE OR<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------------------|---------------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                     | Turbidity.          | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|                     |                     |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.               |                     |                   |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| Jan. 1              | Slight.             | Slight.           | .05    | 21.20                           | 3.40                 | .1040    | .0220       | .0200      | .0020           | 5.32      | .0680          | .0016     | .2194            | 7.4       |
| Feb. 4              | Slight.             | Slight.           | .12    | 18.90                           | 2.40                 | .1000    | .0290       | .0240      | .0050           | 3.60      | .0920          | .0022     | .3215            | 6.4       |
| Feb. 21             | Slight.             | Slight.           | .20    | 18.20                           | 3.00                 | .0920    | .0210       | .0200      | .0010           | 2.70      | .0850          | .0024     | .3783            | 6.1       |
| Mar. 4              | Distinct.           | V. slight.        | .08    | 21.40                           | 3.20                 | .1360    | .0310       | .0220      | .0090           | 4.20      | .1150          | .0020     | .2579            | 7.0       |
| Apr. 1              | Distinct.           | Slight.           | .20    | 13.10                           | 2.80                 | .0840    | .0370       | .0280      | .0090           | 2.39      | .1000          | .0020     | .3041            | 4.4       |
| May 2               | Distinct.           | Slight.           | .18    | 13.80                           | 3.85                 | .0720    | .0180       | .0120      | .0060           | 2.52      | .0930          | .0017     | .3096            | 4.9       |
| June 3              | Distinct,<br>milky. | Slight.           | .18    | 14.80                           | 3.70                 | .0560    | .0340       | .0250      | .0080           | 2.44      | .0600          | .0020     | .3534            | 5.0       |
| July 1              | Distinct.           | Slight.           | .12    | 14.35                           | 2.10                 | .0132    | .0228       | .0176      | .0052           | 2.66      | .0370          | .0015     | .2820            | 4.9       |
| Aug. 1              | Distinct.           | Cons.             | .10    | 15.85                           | 3.25                 | .0076    | .0276       | .0196      | .0080           | 3.00      | .0150          | .0013     | .4004            | 5.3       |
| Sept. 3             | Distinct,<br>green. | Slight,<br>green. | .15    | 15.65                           | 2.25                 | .0008    | .0360       | .0212      | .0148           | 3.50      | .0980          | .0010     | .3195            | 4.9       |
| Oct. 1              | Decided,<br>green.  | Slight,<br>green. | .15    | 15.35                           | 2.55                 | .0000    | .0324       | .0200      | .0124           | 3.60      | .0170          | .0009     | .5714            | 4.9       |
| Nov. 4              | Distinct,<br>brown. | Slight,<br>brown. | .15    | 15.80                           | 3.25                 | .0236    | .0124       | .0104      | .0020           | 3.55      | .0400          | .0014     | .3159            | 5.4       |
| Dec. 2              | Distinct.           | Slight.           | .30    | 13.00                           | 2.50                 | .0670    | .0270       | .0180      | .0090           | 2.65      | .0600          | .0012     | .4306            | 4.6       |
| "                   | "                   | "                 | .15    | 16.07                           | 2.96                 | .0550    | .0271       | .0197      | .0074           | 3.25      | .0585          | .0016     | .3228            | 5.4       |

*Averages by Years.*

|       |   |   |     |       |      |       |       |       |       |      |       |       |       |     |
|-------|---|---|-----|-------|------|-------|-------|-------|-------|------|-------|-------|-------|-----|
| 1887† | - | - | .23 | 10.82 | 1.62 | .0114 | .0266 | -     | -     | 2.06 | .0263 | -     | -     | -   |
| 1888  | - | - | .21 | 10.12 | 1.76 | .0244 | .0267 | -     | -     | 1.94 | .0433 | .0016 | -     | -   |
| 1889  | - | - | .26 | 9.02  | 1.97 | .0211 | .0278 | .0209 | .0069 | 1.67 | .0586 | .0012 | -     | -   |
| 1890  | - | - | .13 | 10.65 | 1.78 | .0197 | .0223 | .0183 | .0040 | 1.57 | .0796 | .0008 | -     | 3.7 |
| 1891  | - | - | .13 | 9.60  | 1.81 | .0188 | .0242 | .0187 | .0055 | 1.58 | .0731 | .0012 | -     | 3.5 |
| 1892  | - | - | .07 | 11.52 | 2.09 | .0185 | .0206 | .0153 | .0053 | 2.22 | .0698 | .0007 | -     | 4.1 |
| 1893  | - | - | .10 | 12.62 | 2.17 | .0240 | .0215 | .0159 | .0056 | 2.49 | .0583 | .0007 | -     | 4.4 |
| 1894  | - | - | .11 | 15.60 | 2.56 | .0381 | .0235 | .0168 | .0067 | 3.48 | .0583 | .0012 | .2608 | 5.2 |
| 1895  | - | - | .15 | 16.07 | 2.96 | .0550 | .0271 | .0197 | .0074 | 3.25 | .0585 | .0016 | .3228 | 5.4 |

Where more than one sample was collected in a month the mean analysis for that month has been in making the average.  
June to December.

NOTE to analyses of 1895: Odor, generally unpleasant or disagreeable; in February and March, etc. The odor was generally stronger on heating.—The samples were collected from the near the gate-house. For monthly record of height of water in this lake, see table at end of Boston rec.

## BOSTON.

MYSTIC SUPPLY. — *Microscopical Examination of Water from Mystic Lake.*

[Number of organisms per cubic centimeter.]

|                           | 1893. |       |       |       |       |       |       |       |       |       |       |       |       |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                           | Jan.  | Feb   | Feb.  | Mar.  | Apr   | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, .     | 2     | 5     | 23    | 6     | 2     | 4     | 3     | 1     | 2     | 4     | 2     | 5     | 3     |
| Number of sample, .       | 13561 | 13739 | 13877 | 13917 | 14056 | 14236 | 14296 | 14555 | 14741 | 14946 | 15277 | 15458 | 15645 |
| PLANTS.                   |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, .             | 1,104 | 43    | 1     | 6     | 2     | 230   | 177   | 6,817 | 4,006 | 1,963 | 1,816 | 1,301 | 527   |
| Asterionella, .           | 0     | 28    | 0     | 2     | 0     | 112   | 2     | 0     | 0     | 0     | 0     | 0     | 0     |
| Fragilaria, .             | 4     | 0     | 0     | 0     | 0     | 3     | 0     | 0     | 6     | 3     | 16    | 0     | 0     |
| Melosira, .               | 0     | 0     | 0     | 0     | 0     | 6     | 0     | 15    | 0     | 0     | 0     | 0     | 7     |
| Navicula, .               | 0     | 0     | 0     | 1     | 1     | 5     | 1     | 2     | 0     | 0     | 0     | 1     | 0     |
| Synedra, .                | 1,100 | 15    | 1     | 3     | 1     | 104   | 174   | 6,800 | 4,000 | 1,960 | 1,800 | 1,300 | 520   |
| Algae, . . . .            | 69    | 4     | 1     | 1     | 5     | 140   | 670   | 148   | 440   | 1,740 | 568   | 224   | 18    |
| Closterium, .             | 0     | 0     | 0     | 0     | 0     | 0     | 22    | 0     | 0     | 0     | 0     | 0     | 0     |
| Pediastrum, .             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1,220 | 0     | 0     | 0     |
| Protococcus, .            | 0     | 0     | 0     | 0     | 0     | 21    | 534   | 0     | 0     | 0     | 0     | 0     | 3     |
| Raphidium, .              | 0     | 0     | 0     | 0     | 0     | 45    | 0     | 0     | 0     | 0     | 4     | 0     | 0     |
| Senedesmus, .             | 68    | 3     | 0     | 0     | 4     | 56    | 113   | 148   | 440   | 520   | 564   | 224   | 14    |
| Zoöspores, .              | 1     | 1     | 1     | 1     | 1     | 18    | 1     | 0     | 0     | 0     | 0     | 0     | 1     |
| Fungi, Crenothrix, .      | 5     | 3     | 52    | 76    | 0     | 15    | 52    | 0     | 0     | 0     | 0     | 0     | 44    |
| ANIMALS.                  |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . .          | 2     | 1     | 3     | 3     | 9     | 22    | 0     | 0     | 116   | 0     | 225   | 0     | 8     |
| Ciliated Infusorian, .    | 0     | 0     | 1     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon, . .            | 0     | 0     | 0     | 0     | 4     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, .        | 0     | 0     | 0     | 0     | 0     | 5     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Euglena, . . .            | 0     | 1     | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Monas, . . . .            | 1     | 0     | 1     | 1     | 1     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 0     |
| Peridinium, .             | 1     | 0     | 0     | 1     | 2     | 0     | 0     | 0     | 116   | 0     | 224   | 0     | 0     |
| Trachelomonas, .          | 0     | 0     | 1     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Vorticella, . .           | 0     | 0     | 0     | 0     | 0     | 8     | 0     | 0     | 0     | 0     | 0     | 0     | 8     |
| Vorticella stems, .       | 0     | 0     | 0     | 0     | 0     | 9     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Vermes, Aurea, .          | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 1     | 0     | 0     | 0     |
| Miscellaneous, Zoöglæa, . | 5     | 600   | 76    | 1,160 | 224   | 180   | 0     | 0     | 0     | 0     | 0     | 220   | 100   |
| TOTAL, . . . .            | 1,185 | 651   | 133   | 1,246 | 240   | 587   | 809   | 6,967 | 4,562 | 3,704 | 2,609 | 1,725 | 697   |

## BOSTON.

**MYSTIC SUPPLY.** — *Chemical Examination of Water from a Faucet in the Charlestown District of Boston.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                  | AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------------------|-------------|-----------|--------|-------------------------|------------------|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition | Free.    | Albuminoid. |            |                 |           | Nitrates.   | Nitrites. |                  |           |
|                     |             |           |        |                         |                  |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |           |
| 1895.<br>Feb. 21    | Slight.     | Slight.   | .10    | 20.70                   | 2.90             | .1120    | .0190       | .0150      | .0040           | 3.85      | .0850       | .0030     | .2457            | 6.7       |

Odor, decidedly musty and very disagreeable. — The sample was collected at the State Prison.

*Microscopical Examination.*

Diatomaceæ, *Asterionella*, 5; *Synedra*, 17. Algae, *Zoosporas*, 3. Fungi, *Crenothrix*, 68. Infusoria, *used Infusorian*, 1. Miscellaneous, *Zooglaea*, 184. Total, 278.

*Showing the Heights in Feet above Tide-marsh Level on the First of Each Month of the Water in the Lakes and Storage Reservoirs of the Boston Water Works, from which Samples of Water were collected during the Year 1895.*

| 1895. | Reservoir No. 2.<br>Flash Boards,<br>167.12. | Reservoir No. 3.<br>Stone Crest,<br>175.24. | Reservoir No. 4.<br>Flash Boards,<br>215.21. | Reservoir No. 6.<br>Flash Boards,<br>256.00. | Farm Pond.<br>High Water,<br>149.25. | Lake Cochituate.<br>High Water,<br>134.36. | Mystic Lake.<br>High Water,<br>7 00. |
|-------|----------------------------------------------|---------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------------------|--------------------------------------------|--------------------------------------|
| 1, .  | 166.00                                       | 175.24                                      | 196.18                                       | 278.84                                       | 148.79                               | 126.28                                     | 3.37                                 |
| 1, .  | 166.06                                       | 175.45                                      | 201.65                                       | 283.48                                       | 149.06                               | 128.90                                     | 4.88                                 |
| 1, .  | 161.22                                       | 172.47                                      | 203.79                                       | 285.21                                       | 149.01                               | 126.50                                     | 3.18                                 |
| 1, .  | 166.16                                       | 175.66                                      | 212.91                                       | 293.42                                       | 149.35                               | 132.97                                     | 6.47                                 |
| 1, .  | 166.09                                       | 175.37                                      | 214.60                                       | 294.28                                       | 149.63                               | 134.35                                     | 6.48                                 |
| 1, .  | 166.05                                       | 174.68                                      | 215.34                                       | 295.02                                       | 149.32                               | 134.04                                     | 6.80                                 |
| 1, .  | 164.23                                       | 169.46                                      | 215.81                                       | 295.04                                       | 149.01                               | 133.09                                     | 4.67                                 |
| 1, .  | 163.97                                       | 170.47                                      | 210.25                                       | 290.58                                       | 149.00                               | 131.72                                     | 4.20                                 |
| 1, .  | 163.30                                       | 172.50                                      | 203.98                                       | 283.91                                       | 148.89                               | 130.20                                     | 5.87                                 |
| 1, .  | 163.14                                       | 172.57                                      | 194.41                                       | 273.64                                       | 148.58                               | 128.98                                     | 3.23                                 |
| 1, .  | 167.15                                       | 175.66                                      | 197.35                                       | 279.19                                       | 149.27                               | 129.63                                     | 6.75                                 |
| 1, .  | 166.23                                       | 175.77                                      | 207.83                                       | 289.92                                       | 149.36                               | 132.71                                     | 6.23                                 |

**WATER SUPPLY OF BRADFORD.**

On the advice of the State Board of Health to the Bradford Water Company, relative to the introduction of a new supply from Johnson's Pond in Boxford and Groveland and as to the improvement of the existing supply, is given on pages 15 and 16 of this volume. Analyses of samples of water from Johnson's Pond may be found on page 164 of the annual report for 1894.

The works of the Bradford Water Company were taken by the State of Bradford on April 1, 1895, and works for the introduction of a new supply from Johnson's Pond were partially constructed at the end of 1895, but as yet no water has been supplied to the town from this source.

## BRAINTREE.

## WATER SUPPLY OF BRAINTREE.

1 August, September and October the water from the Braintree r-gallery was affected by the presence of an excessive amount of iron, as will be seen by reference to the analyses in the table below.

Iron oxidizes on exposure to the air and precipitates, causing a milky turbidity and then a rusty precipitate. Information as to the effect of the presence of iron in ground waters may be found in the explanatory note on page 75.

*Chemical Examination of Water from the Filler-gallery of the Braintree Water Works.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE.    |               |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------------------|----------------|---------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|                     | Turbidity.     | Sediment.     | Color. |                         | Free.    | Alb. minoid |           | Nitrates.   | Nitrites. |                  |           |       |
| <b>1895.</b>        |                |               |        |                         |          |             |           |             |           |                  |           |       |
| Jan. 7              | None.          | V. slight.    | .07    | 6.10                    | .0000    | .0070       | 1.01      | .0780       | .0000     | .0936            | 2.2       | .0020 |
| Feb. 7              | None.          | V. slight.    | .08    | 5.35                    | .0004    | .0086       | 0.94      | .0630       | .0000     | .1935            | 2.1       | .0060 |
| Mar. 6              | None.          | None.         | .03    | 5.35                    | .0002    | .0062       | 0.94      | .0480       | .0000     | .1555            | 1.7       | .0025 |
| Apr. 3              | None.          | None.         | .12    | 4.75                    | .0000    | .0068       | 0.83      | .0470       | .0000     | .1963            | 1.7       | .0100 |
| May 7               | None.          | None.         | .15    | 4.90                    | .0000    | .0078       | 0.82      | .0270       | .0000     | .2002            | 1.4       | .0030 |
| June 5              | None.          | None.         | .04    | 5.05                    | .0004    | .0074       | 0.85      | .0350       | .0000     | .1315            | 1.7       | .0045 |
| July 11             | V. slight.     | V. slight.    | .18    | 4.70                    | .0018    | .0070       | 0.80      | .0130       | .0016     | .1659            | 1.3       | .0150 |
| Aug. 8              | None.          | V. slight.    | .20    | 5.35                    | .0004    | .0040       | 0.84      | .0070       | .0001     | .1092            | 2.0       | .0650 |
| Sept. 5             | Slight, milky. | Cons., rusty. | .02    | 5.40                    | .0010    | .0060       | 0.82      | .0020       | .0004     | .0936            | 1.6       | .2150 |
| Oct. 7              | Distinct.      | Slight.       | .48    | 5.00                    | .0002    | .0030       | 0.89      | .0030       | .0002     | .1014            | 1.9       | .1600 |
| Nov. 6              | None.          | None.         | .05    | 6.25                    | .0002    | .0040       | 1.00      | .0400       | .0002     | .0858            | 2.1       | .0050 |
| Dec. 4              | None.          | V. slight.    | .05    | 5.70                    | .0006    | .0042       | 0.97      | .0790       | .0000     | .0717            | 2.9       | .0130 |
| .....               | .....          | .....         | .12    | 5.32                    | .0004    | .0060       | 0.89      | .0369       | .0002     | .1332            | 2.0       | .0417 |

## Averages by Years.

| Year. | Turbidity. | Sediment. | Color. | Residue on Evaporation. | Free Ammonia. | Alb. minoid | Chlorine. | Nitrates. | Nitrites. | Oxygen Consumed. | Hardness. | Iron. |
|-------|------------|-----------|--------|-------------------------|---------------|-------------|-----------|-----------|-----------|------------------|-----------|-------|
| 1892  | —          | —         | .07    | 7.14                    | .0006         | .0045       | 0.85      | .0948     | .0003     | —                | —         | —     |
| 1893  | —          | —         | .02    | 4.69                    | .0002         | .0030       | 0.75      | .0122     | .0001     | —                | 1.8       | —     |
| 1894  | —          | —         | .03    | 4.72                    | .0002         | .0049       | 0.83      | .0363     | .0001     | .1029            | 1.8       | .0037 |
| 1895  | —          | —         | .04    | 5.19                    | .0004         | .0048       | 0.86      | .0338     | .0001     | .1000            | 1.7       | .0135 |
| 1896  | —          | —         | .12    | 5.32                    | .0004         | .0060       | 0.89      | .0369     | .0002     | .1332            | 2.0       | .0417 |

\* June, 1887, to May, 1888.

As to analyses of 1895: Odor, in January and July, distinctly vegetable; in February and October, earthy; in November, faintly sweetish; at other times, none. In January and November the odor appeared on heating. — The samples were collected from a faucet at the pumping station.

**BRAINTREE.***Microscopical Examination of Water from the Filler-gallery of the Braintree Water Works.*

[Number of organisms per cubic centimeter.]

|                                     | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|-------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                     | Jan.  | Feb.  | Mar.  | Apr.  | May   | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . . .       | 8     | 7     | 8     | 4     | 8     | 7     | 12    | 10    | 7     | 8     | 8     | 5     |
| Number of sample, . . . . .         | 13607 | 13777 | 13932 | 14089 | 14253 | 14434 | 14613 | 14790 | 14997 | 15312 | 15486 | 15680 |
| <b>PLANTS.</b>                      |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, Asterionella, . . . . . | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 8     | 0     |
| Fungi, Crenothrix, . . . . .        | 2     | 0     | 5     | 0     | 0     | 0     | 400   | 110   | 40    | 52    | 10    | 2     |
| <b>ANIMALS.</b>                     |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, Trachelomonas, . . . . . | 0     | 1     | 0     | 0     | pr.   | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Miscellaneous, Zoöglan, . . . . .   | 0     | 0     | 15    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 52    | 0     |
| <b>TOTAL,</b> . . . . .             | 2     | 1     | 20    | 0     | pr.   | 0     | 400   | 110   | 40    | 52    | 80    | 2     |

**WATER SUPPLY OF BRIDGEWATER AND EAST BRIDGEWATER. —  
BRIDGEWATERS WATER COMPANY.**

During the year 1895 nine tubular wells, each 6 inches in diameter, were added to the works. These wells are located about 1,000 feet east of the pumping station, in a line at right angles to the course of the river, and are about 200 feet apart in the line. They are from 90 to 165 feet in depth and are sunk in rock, the surface of which is from 30 to 50 feet beneath the surface of the ground. An analysis of a sample of water from one of the wells, which is 160 feet deep, is given on the following page.

*Chemical Examination of Water from the Wells of the Bridgewaters Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|-----------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                 |           |       |
| 14595   | 1895.<br>July 10    | V. slight.  | V. slight. | .00    | 4.85                    | .0008    | .0002       | .43       | .0130       | .0000     | .0237           | 1.1       | .0110 |

Odor, none. — The sample was collected from a faucet at the pumping station.

*Microscopical Examination.*

No organisms.

## BRIDGEWATER AND EAST BRIDGEWATER.

*Chemical Examination of Water from a New Tubular Well of the Bridgewater Water Company.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE.    |           |        | Residue on Evaporation. | AMMONIA. |             |  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------------------|----------------|-----------|--------|-------------------------|----------|-------------|--|-----------|-------------|-----------|------------------|-----------|-------|
|                     | Turbidity.     | Sediment. | Color. |                         | Free.    | Albuminoid. |  |           | Nitrates.   | Nitrites. |                  |           |       |
| 1895.<br>May 30     | Slight, milky. | None.     | .20    | 10.90                   | .0014    | .0006       |  | .36       | .0040       | .0000     | .0076            | 4.0       | .0690 |

Odor, none. — The sample was collected from a new tubular well 160 feet in depth and located 1,000 feet east of the pumping station.

*Microscopical Examination.*

To organisms.

## WATER SUPPLY OF BROCKTON.

*Chemical Examination of Water from Salisbury Brook Storage Reservoir, Brockton.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>as |           | Oxygen Consumed. | Hardness. |
|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.               |             |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| Jan. 7              | V. slight.  | V. slight. | 1.00   | 4.80                            | 2.15                 | .0002    | .0268       | .0228      | .0040           | .48       | .0000          | .0000     | .8658            | 1.3       |
| Mar. 11             | Slight.     | Slight.    | 0.70   | 3.85                            | 1.70                 | .0002    | .0224       | .0170      | .0054           | .41       | .0000          | .0000     | .7130            | 0.9       |
| Apr. 8              | Slight.     | Slight.    | 0.58   | 3.85                            | 1.60                 | .0012    | .0210       | .0196      | .0014           | .38       | .0020          | .0000     | .5513            | 0.8       |
| May 8               | Slight.     | Cons.      | 0.80   | 3.05                            | 1.75                 | .0006    | .0192       | .0170      | .0022           | .38       | .0000          | .0000     | .6314            | 0.5       |
| June 10             | Distinct.   | Cons.      | 0.90   | 3.30                            | 1.95                 | .0000    | .0280       | .0240      | .0020           | .39       | .0030          | .0000     | .7752            | 0.8       |
| July 15             | Distinct.   | Cons.      | 0.90   | 3.70                            | 1.90                 | .0006    | .0276       | .0244      | .0032           | .42       | .0050          | .0000     | .8346            | 0.6       |
| Aug. 12             | Distinct.   | Slight.    | 0.75   | 3.80                            | 2.00                 | .0004    | .0296       | .0230      | .0066           | .46       | .0030          | .0001     | .7176            | 1.4       |
| Sept. 9             | Distinct.   | Slight.    | 0.67   | 3.50                            | 1.70                 | .0000    | .0298       | .0230      | .0068           | .46       | .0000          | .0000     | .6240            | 1.3       |
| Oct. 8              | Distinct.   | Slight.    | 0.52   | 3.20                            | 1.60                 | .0000    | .0280       | .0244      | .0036           | .48       | .0000          | .0000     | .6444            | 0.8       |
| Nov. 12             | Slight.     | Slight.    | 0.93   | 4.05                            | 2.20                 | .0044    | .0348       | .0284      | .0064           | .48       | .0070          | .0000     | .9321            | 0.8       |
| Dec. 9              | V. slight.  | Slight.    | 1.10   | 4.10                            | 1.95                 | .0018    | .0236       | .0228      | .0008           | .35       | .0000          | .0000     | .9516            | 0.8       |
| .....               | .....       | .....      | 0.80   | 3.75                            | 1.86                 | .0009    | .0263       | .0224      | .0039           | .43       | .0018          | .0000     | .7401            | 0.9       |

*Averages by Years.*

|       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| 1887* | - | - | 0.99 | 4.94 | 2.25 | .0033 | .0541 | -     | -     | .33 | .0069 | -     | -     | -   |
| 1888  | - | - | 0.76 | 3.77 | 1.61 | .0031 | .0369 | -     | -     | .31 | .0066 | .0001 | -     | -   |
| 1889  | - | - | 0.78 | 2.79 | 1.01 | .0028 | .0306 | .0218 | .0078 | .30 | .0048 | .0002 | -     | -   |
| 1890  | - | - | 0.75 | 4.07 | 1.98 | .0016 | .0274 | .0219 | .0055 | .32 | .0063 | .0001 | -     | 0.9 |
| 1891  | - | - | 0.62 | 3.15 | 1.45 | .0010 | .0213 | .0169 | .0044 | .28 | .0061 | .0001 | -     | 0.6 |
| 1892  | - | - | 0.55 | 3.41 | 1.37 | .0004 | .0213 | .0168 | .0045 | .36 | .0030 | .0000 | -     | 0.7 |
| 1893  | - | - | 0.67 | 3.59 | 1.70 | .0007 | .0237 | .0196 | .0041 | .40 | .0019 | .0001 | .6545 | 0.7 |
| 1894  | - | - | 0.81 | 3.71 | 1.63 | .0012 | .0228 | .0188 | .0040 | .44 | .0021 | .0000 | .6633 | 0.7 |
| 1895  | - | - | 0.80 | 3.75 | 1.86 | .0009 | .0263 | .0224 | .0039 | .43 | .0018 | .0000 | .7401 | 0.9 |

\* June to December.

As to analyses of 1895: Odor, vegetable, frequently becoming somewhat stronger on heating. —  
 pies were collected from the reservoir near the gate-house, 1 foot beneath the surface. For  
 record of height of water in this reservoir, see page 125.



## BROCKTON.

*Showing Height of Water in Salisbury Brook Storage Reservoir, Brockton, on the First Day of Each Month in 1895.*

[NOTE.—High-water mark is 14.25 feet.]

| DATE.      | Height of Water. | DATE.            | Height of Water. |
|------------|------------------|------------------|------------------|
| 1895.      | Feet.            | 1895.            | Feet.            |
| 1. . . . . | 14.75            | July 1. . . . .  | 13.87            |
| 1. . . . . | 14.84            | Aug. 1. . . . .  | 13.04            |
| 1. . . . . | 14.33            | Sept. 1. . . . . | 11.58            |
| 1. . . . . | 14.54            | Oct. 1. . . . .  | 10.35            |
| 1. . . . . | 15.58            | Nov. 1. . . . .  | 13.50            |
| 1. . . . . | 15.33            | Dec. 1. . . . .  | 14.79            |

\* About April 1, 1895, the water was raised temporarily 18 inches above high-water mark.

## WATER SUPPLY OF BROOKFIELD.

The advice of the State Board of Health to the town of Brookfield, relative to taking an additional supply of water from South Pond in that town, may be found on pages 16 and 17 of this volume. Analyses of samples of water collected during the investigation for additional supply are given below.

*Chemical Examination of Water from South Pond, Brookfield.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.               |             |           |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| Mar. 18             | V. slight.  | Cons.     | .28    | 3.30                            | 0.80                 | .0036    | .0168       | .0154      | .0014           | .19       | .0000          | .0000     | .3002            | 1.9       |
| May 23              | Slight.     | Slight.   | .05    | 2.40                            | 0.60                 | .0000    | .0122       | .0108      | .0014           | .19       | .0000          | .0000     | .1520            | 0.8       |
| May 29              | Slight.     | Slight.   | .05    | 2.95                            | 1.10                 | .0000    | .0104       | .0072      | .0032           | .18       | .0000          | .0000     | .1558            | 0.9       |

lor, vegetable. — The first sample was collected from the pond, at the outlet; the second, near Mt of Pines; the third, at the deepest part near the centre.

**BROOKFIELD.***Microscopical Examination of Water from South Pond, Brookfield.*

[Number of organisms per cubic centimeter.]

|                                   | 1895.  |       |       |
|-----------------------------------|--------|-------|-------|
|                                   | March. | May.  | May.  |
| Day of examination, . . . . .     | 19     | 25    | 31    |
| Number of sample, . . . . .       | 13994  | 14361 | 14385 |
| <b>PLANTS.</b>                    |        |       |       |
| Diatomaceæ, . . . . .             | 37     | 221   | 259   |
| Amphipleura, . . . . .            | 0      | 3     | 0     |
| Asterionella, . . . . .           | 8      | 8     | 42    |
| Cyclotella, . . . . .             | 3      | 44    | 128   |
| Diatoma, . . . . .                | 2      | 5     | 0     |
| Fragilaria, . . . . .             | 2      | 4     | 0     |
| Melosira, . . . . .               | 2      | 5     | 0     |
| Navicula, . . . . .               | 1      | 4     | 0     |
| Pinnularia, . . . . .             | 0      | 2     | 1     |
| Synedra, . . . . .                | 2      | 2     | 4     |
| Tabellaria, . . . . .             | 17     | 144   | 84    |
| Cyanophyceæ, Anabæna, . . . . .   | 0      | 0     | 8     |
| Fungi, Crenothrix, . . . . .      | 3      | 0     | 0     |
| <b>ANIMALS.</b>                   |        |       |       |
| Infusoria, . . . . .              | 3      | 0     | 13    |
| Dinobryon cases, . . . . .        | 2      | 0     | 0     |
| Mallomonas, . . . . .             | 1      | 0     | 0     |
| Vorticella, . . . . .             | 0      | 0     | 13    |
| Miscellaneous, Zoöglæa, . . . . . | 3      | 116   | 0     |
| TOTAL, . . . . .                  | 46     | 337   | 280   |

*Chemical Examination of Water from Five Mile River and Furnace Pond, Brookfield.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.   |                     |             |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 14013   | Mar. 20             | V. allght.  | Cons.      | .42    | 2.70                            | 0.55                 | .0008    | .0134       | .0122      | .0012           | .16       | .0050          | .0001     | .4519            | 1.3       |
| 14014   | Mar. 20             | Slight.     | V. allght. | .38    | 3.85                            | 1.45                 | .0034    | .0170       | .0150      | .0020           | .17       | .0050          | .0001     | .4266            | 1.3       |
| 14362   | May 23              | Slight.     | Slight.    | .38    | 2.95                            | 0.65                 | .0002    | .0140       | .0126      | .0014           | .18       | .0000          | .0000     | .4142            | 0.8       |
| 14363   | May 23              | Slight.     | Slight.    | .28    | 2.40                            | 0.75                 | .0010    | .0152       | .0128      | .0024           | .19       | .0000          | .0000     | .6574            | 0.6       |
| 14435   | June 6              | Distinct.   | Slight.    | .26    | 3.30                            | 1.36                 | .0000    | .0198       | .0182      | .0016           | .16       | .0030          | .0000     | .3835            | 0.6       |
| 14484   | June 18             | Slight.     | Slight.    | .25    | 3.05                            | 1.00                 | .0002    | .0138       | .0120      | .0018           | .15       | .0030          | .0000     | .3182            | 0.6       |

Odor, vegetable. — The first two samples were collected from the Five Mile River just above its entrance into Furnace Pond; the remaining samples from Furnace Pond near its outlet.

## BROOKFIELD.

*Optical Examination of Water from Five Mile River and Furnace Pond,  
Brookfield.*

[Number of organisms per cubic centimeter.]

|                         | 1893.  |       |        |       |       |       |
|-------------------------|--------|-------|--------|-------|-------|-------|
|                         | March. | May.  | March. | May.  | June. | June. |
| amination, . . . . .    | 21     | 25    | 21     | 25    | 7     | 19    |
| of sample, . . . . .    | 14013  | 14362 | 14014  | 14363 | 14435 | 14484 |
| PLANTS.                 |        |       |        |       |       |       |
| aceae, . . . . .        | 25     | 350   | 4      | 164   | 618   | 294   |
| tonella, . . . . .      | 2      | 0     | 0      | 14    | 4     | 8     |
| onella, . . . . .       | 0      | 1     | 0      | 0     | 0     | 0     |
| tella, . . . . .        | 0      | 1     | 0      | 80    | 588   | 268   |
| ma, . . . . .           | 2      | 0     | 0      | 0     | 0     | 0     |
| laria, . . . . .        | 0      | 4     | 0      | 0     | 0     | 0     |
| dra, . . . . .          | 9      | 18    | 0      | 22    | 3     | 0     |
| ula, . . . . .          | 0      | 0     | 0      | 1     | 0     | 1     |
| ira, . . . . .          | 9      | 76    | 4      | 28    | 1     | 2     |
| laria, . . . . .        | 3      | 250   | 0      | 19    | 22    | 15    |
| hyceae, Anabaena, . .   | 0      | 0     | 0      | 0     | 70    | 11    |
| . . . . .               | 0      | 10    | 0      | 21    | 3     | 4     |
| ococcus, . . . . .      | 0      | 4     | 0      | 0     | 0     | 0     |
| idium, . . . . .        | 0      | 1     | 0      | 0     | 0     | 0     |
| coccus, . . . . .       | 0      | 0     | 0      | 20    | 3     | 4     |
| idium, . . . . .        | 0      | 1     | 0      | 0     | 0     | 0     |
| desmus, . . . . .       | 0      | 4     | 0      | 1     | 0     | 0     |
| Crenothrix, . . . . .   | 0      | 100   | 0      | 1     | 0     | 0     |
| ANIMALS.                |        |       |        |       |       |       |
| ia, . . . . .           | 21     | 99    | 84     | 1     | 0     | 1     |
| ryon cases, . . . . .   | 0      | 96    | 88     | 0     | 0     | 0     |
| na, . . . . .           | 4      | 0     | 3      | 0     | 0     | 0     |
| monas, . . . . .        | 0      | 0     | 0      | 0     | 0     | 1     |
| s, . . . . .            | 1      | 1     | 0      | 0     | 0     | 0     |
| inlum, . . . . .        | 16     | 2     | 3      | 0     | 0     | 0     |
| anidium, . . . . .      | 0      | 0     | 0      | 1     | 0     | 0     |
| s, . . . . .            | 0      | 0     | 0      | 3     | 0     | 1     |
| ea, . . . . .           | 0      | 0     | 0      | 2     | 0     | 1     |
| rtara, . . . . .        | 0      | 0     | 0      | 1     | 0     | 0     |
| occus, Zoëglia, . . . . | 0      | 0     | 280    | 88    | 0     | 0     |
| L, . . . . .            | 46     | 559   | 358    | 278   | 691   | 311   |

**BROOKFIELD.***Chemical Examination of Water from Rice's Mill-pond, Brookfield.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.   |                     |             |           |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 14012   | Mar. 20             | Slight.     | Slight.   | .38    | 3.45                    | 1.40              | .0020    | .0186       | .0158      | .0028      | .16       | .0030       | .0001     | .4756            | 1.3       |
| 14384   | May 29              | Distinct.   | Cons.     | .68    | 3.40                    | 1.90              | .0020    | .0226       | .0204      | .0022      | .16       | .0000       | .0000     | .6574            | 0.9       |

Odor of the first sample, vegetable; of the second, none, becoming distinctly vegetable on heating.

— The samples were collected from Rice's mill-pond, about one mile south of Brookfield village, on the stream which joins the Quabog River near the Brookfield station of the Boston & Albany Railroad.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 14012, 159; No. 14384, 228.

**WATER SUPPLY OF BROOKLINE.***Chemical Examination of Water from a Faucet at the Low-service Pumping Station of the Brookline Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         |                     |             |           |        |                         |          |                  |           |             |           |                  |           |       |
| 1895.   |                     |             |           |        |                         |          |                  |           |             |           |                  |           |       |
| 13735   | Jan. 31             | None.       | None.     | .00    | 9.90                    | .0006    | .0032            | .68       | .0450       | .0000     | .0671            | 4.7       | .0000 |
| 13833   | Feb. 18             | None.       | None.     | .01    | 9.40                    | .0000    | .0024            | .64       | .0450       | .0000     | .0663            | 4.3       | .0010 |
| 13990   | Mar. 18             | None.       | None.     | .03    | 9.10                    | .0000    | .0018            | .63       | .0330       | .0000     | .0806            | 4.6       | .0020 |
| 14144   | Apr. 15             | None.       | None.     | .02    | 8.60                    | .0004    | .0036            | .53       | .0280       | .0000     | .1343            | 4.4       | .0010 |
| 14301   | May 14              | None.       | None.     | .03    | 8.90                    | .0004    | .0018            | .56       | .0400       | .0000     | .0790            | 4.3       | .0020 |
| 14509   | June 19             | None.       | None.     | .03    | 9.40                    | .0000    | .0028            | .60       | .0380       | .0000     | .0390            | 4.4       | .0000 |
| 14707   | July 24             | None.       | None.     | .01    | 9.15                    | .0010    | .0022            | .64       | .0280       | .0000     | .0847            | 4.6       | .0015 |
| 14809   | Aug. 19             | None.       | None.     | .01    | 9.60                    | .0010    | .0020            | .60       | .0400       | .0000     | .0780            | 4.7       | .0100 |
| 15180   | Sept. 16            | None.       | None.     | .03    | 8.50                    | .0010    | .0022            | .60       | .0350       | .0000     | .0585            | 4.2       | .0020 |
| 15361   | Oct. 11             | None.       | None.     | .07    | 8.90                    | .0000    | .0018            | .60       | .0400       | .0000     | .0718            | 4.6       | .0020 |
| 15567   | Nov. 18             | None.       | None.     | .02    | 9.00                    | .0004    | .0038            | .61       | .0280       | .0000     | .0975            | 4.2       | .0030 |
| 15735   | Dec. 16             | None.       | None.     | .04    | 9.20                    | .0010    | .0038            | .56       | .0330       | .0000     | .0585            | 4.4       | .0020 |
| Av.     | 1895                | .....       | .....     | .02    | 9.15                    | .0005    | .0026            | .60       | .0361       | .0000     | .0719            | 4.4       | .0022 |
| Av.     | 1894                | .....       | .....     | .02    | 9.01                    | .0010    | .0017            | .65       | .0308       | .0001     | .0593            | 4.5       | .0035 |

NOTE to analyses of 1895: Odor, none — The samples were collected from a faucet at the low-service pumping station located near the Charles River, in the West Roxbury District of the city of Boston, and represent a mixture of water from the filter-gallery and tubular wells.

*Microscopical Examination.*

An insignificant number of organisms, generally *Crenothrix*, was found in these samples.

BROOKLINE.

Chemical Examination of Water from the Covered Reservoir of the Brookline Water Works.

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 1895.   |                     |             |            |        |                         |          |                  |           |             |           |                  |           |       |
| 734     | Jan. 31             | None.       | None.      | .00    | 9.10                    | .0000    | .0026            | .68       | .0400       | .0000     | .0577            | 4.7       | .0000 |
| 832     | Feb. 18             | None.       | None.      | .04    | 9.60                    | .0000    | .0022            | .63       | .0430       | .0000     | .0702            | 4.6       | .0000 |
| 991     | Mar. 18             | None.       | None.      | .02    | 8.10                    | .0000    | .0028            | .59       | .0300       | .0000     | .0885            | 4.6       | .0020 |
| 147     | Apr. 16             | None.       | V. slight. | .01    | 8.50                    | .0002    | .0020            | .58       | .0380       | .0000     | .0932            | 4.5       | .0010 |
| 300     | May 14              | None.       | None.      | .03    | 9.10                    | .0000    | .0014            | .59       | .0420       | .0000     | .0869            | 4.3       | .0100 |
| 510     | June 19             | None.       | None.      | .03    | 9.00                    | .0000    | .0026            | .60       | .0230       | .0000     | .0296            | 4.4       | .0070 |
| 708     | July 24             | None.       | None.      | .01    | 8.25                    | .0000    | .0018            | .63       | .0280       | .0000     | .0770            | 4.7       | .0050 |
| 868     | Aug. 19             | None.       | None.      | .02    | 9.70                    | .0000    | .0020            | .57       | .0450       | .0000     | .0780            | 4.3       | .0030 |
| 179     | Sept. 16            | None.       | None.      | .02    | 8.50                    | .0004    | .0028            | .58       | .0330       | .0000     | .0686            | 4.2       | .0020 |
| 362     | Oct. 11             | None.       | V. slight. | .07    | 8.80                    | .0000    | .0016            | .60       | .0400       | .0000     | .0718            | 4.4       | .0010 |
| 568     | Nov. 19             | None.       | None.      | .03    | 9.30                    | .0002    | .0032            | .61       | .0250       | .0000     | .1053            | 4.3       | .0050 |
| 736     | Dec. 16             | None.       | V. slight. | .04    | 8.80                    | .0008    | .0042            | .57       | .0280       | .0000     | .0993            | 4.3       | .0020 |
| iv.     | 1895                | .....       | .....      | .03    | 8.90                    | .0001    | .0024            | .60       | .0346       | .0000     | .0747            | 4.5       | .0032 |
| iv.     | 1894                | .....       | .....      | .02    | 9.15                    | .0001    | .0017            | .63       | .0363       | .0000     | .0566            | 4.4       | .0025 |

NOTE to analyses of 1895: Odor, none. — The samples were collected from the reservoir.

Microscopical Examination.

An insignificant number of organisms, generally *Oreothrix*, was found in these samples.

Chemical Examination of Water from Charles River, opposite the Filler-gallery of the Brookline Water Works at West Roxbury.

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.               |             |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| Jan. 31             | V. slight.  | Slight.    | 0.75   | 4.55                            | 1.95                 | .0004    | .0192       | .0184      | .0008           | .37       | .0200          | .0000     | .7386            | 1.4       |
| Apr. 15             | Slight.     | Slight.    | 0.80   | 3.85                            | 2.00                 | .0006    | .0226       | .0202      | .0024           | .34       | .0020          | .0000     | .8374            | 1.2       |
| May 14              | V. slight.  | Slight.    | 1.40   | 5.10                            | 2.85                 | .0016    | .0288       | .0274      | .0014           | .37       | .0070          | .0000     | 1.1202           | 1.6       |
| June 19             | Slight.     | Slight.    | 1.00   | 4.30                            | 2.10                 | .0000    | .0272       | .0210      | .0062           | .34       | .0070          | .0002     | .7059            | 1.6       |
| July 24             | Slight.     | Slight.    | 1.00   | 5.00                            | 2.00                 | .0016    | .0258       | .0226      | .0032           | .49       | .0030          | .0000     | .8162            | 1.6       |
| Aug 19              | V. slight.  | Slight.    | 0.45   | 4.80                            | 1.90                 | .0002    | .0210       | .0192      | .0018           | .46       | .0030          | .0000     | .5928            | 1.6       |
| Sept. 16            | V. slight.  | Slight.    | 0.40   | 5.00                            | 1.60                 | .0000    | .0174       | .0166      | .0008           | .53       | .0030          | .0001     | .4446            | 1.6       |
| Oct. 11             | Distinct.   | Slight.    | 0.88   | 5.20                            | 2.05                 | .0002    | .0252       | .0212      | .0040           | .60       | .0100          | .0001     | .5476            | 1.7       |
| Nov. 18             | Slight.     | Slight.    | 1.20   | 5.15                            | 2.85                 | .0006    | .0258       | .0238      | .0020           | .44       | .0070          | .0001     | 1.3650           | 1.4       |
| Dec. 16             | V. slight.  | V. slight. | 1.10   | 5.45                            | 2.35                 | .0014    | .0234       | .0222      | .0012           | .56       | .0600          | .0001     | .9394            | 1.4       |
|                     |             |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| .....               | .....       | .....      | 0.85   | 4.84                            | 2.16                 | .0007    | .0236       | .0212      | .0024           | .45       | .0122          | .0001     | .8108            | 1.5       |

odor, distinctly vegetable and frequently mouldy.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 56.

## CAMBRIDGE.

## WATER SUPPLY OF CAMBRIDGE.

*Chemical Examination of Water from Fresh Pond, Cambridge.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.        | Sediment.       | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                   |                 |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13584   | Jan. 2              | V. slight.        | Cons.           | .45    | 7.60                    | 1.80              | .0110    | .0212       | .0200      | .0012      | 0.73      | .0230       | .0000     | .3835            | 3.6       |
| 13753   | Feb. 6              | Slight.           | Slight.         | .40    | 7.65                    | 1.75              | .0004    | .0186       | .0170      | .0016      | 0.73      | .0300       | .0000     | .4740            | 3.5       |
| 13918   | Mar. 5              | V. slight.        | V. slight.      | .33    | 7.55                    | 2.40              | .0008    | .0204       | .0194      | .0010      | 0.72      | .0380       | .0000     | .4812            | 3.5       |
| 14079   | Apr. 2              | Distinct.         | Cons.           | .33    | 7.45                    | 2.00              | .0002    | .0236       | .0196      | .0040      | 0.66      | .0380       | .0001     | .4427            | 2.9       |
| 14244   | May 6               | Distinct.         | Cons.           | .40    | 7.15                    | 2.55              | .0034    | .0230       | .0184      | .0046      | 0.70      | .0230       | .0003     | .4466            | 3.5       |
| 14424   | June 4              | Distinct.         | Cons.           | .30    | 7.00                    | 2.15              | .0072    | .0244       | .0194      | .0050      | 0.63      | .0220       | .0003     | .4978            | 3.1       |
| 14587   | July 9              | Distinct.         | Cons.           | .38    | 6.70                    | 2.45              | .0078    | .0248       | .0200      | .0048      | 0.63      | .0220       | .0006     | .5214            | 3.1       |
| 14769   | Aug. 6              | Distinct.         | Cons.           | .28    | 6.75                    | 1.65              | .0016    | .0274       | .0212      | .0062      | 0.76      | .0180       | .0004     | .5382            | 3.5       |
| 14945   | Sept. 3             | Distinct, white.  | Slight, green.  | .20    | 7.25                    | 1.95              | .0000    | .0340       | .0176      | .0164      | 0.67      | .0030       | .0003     | .4235            | 3.0       |
| 15296   | Oct. 2              | Distinct, green.  | Cons., green.   | .25    | 7.30                    | 1.75              | .0008    | .0328       | .0182      | .0136      | 0.66      | .0080       | .0003     | .4017            | 2.9       |
| 15474   | Nov. 5              | Distinct, clayey. | Slight.         | .37    | 8.25                    | 2.60              | .0270    | .0224       | .0182      | .0042      | 0.70      | .0120       | .0012     | .5109            | 3.6       |
| 15659   | Dec. 3              | Distinct, clayey. | Slight, yellow. | .50    | 8.50                    | 2.80              | .0046    | .0212       | .0178      | .0034      | 0.71      | .0280       | .0020     | .4680            | 3.6       |
| Av.     | .....               | .....             | .....           | .35    | 7.43                    | 2.15              | .0054    | .0245       | .0189      | .0055      | 0.69      | .0221       | .0004     | .4658            | 3.3       |

*Averages by Years.*

|   |       |   |   |     |       |      |       |       |       |       |      |       |       |       |     |
|---|-------|---|---|-----|-------|------|-------|-------|-------|-------|------|-------|-------|-------|-----|
| - | 1887* | - | - | .04 | 17.32 | 1.94 | .0105 | .0180 | -     | -     | 2.11 | .0266 | -     | -     | -   |
| - | 1888  | - | - | .17 | 11.11 | 1.79 | .0132 | .0206 | -     | -     | 1.10 | .0261 | .0007 | -     | -   |
| - | 1889  | - | - | .11 | 9.86  | 1.83 | .0145 | .0220 | .0170 | .0050 | 0.90 | .0334 | .0008 | -     | -   |
| - | 1890  | - | - | .11 | 8.87  | 1.41 | .0098 | .0221 | .0168 | .0053 | 0.83 | .0303 | .0004 | -     | 4.1 |
| - | 1891  | - | - | .15 | 7.94  | 1.80 | .0095 | .0235 | .0162 | .0073 | 0.75 | .0333 | .0004 | -     | 5.9 |
| - | 1892  | - | - | .16 | 7.23  | 1.57 | .0086 | .0210 | .0161 | .0049 | 0.67 | .0249 | .0003 | -     | 3.4 |
| - | 1893  | - | - | .27 | 6.66  | 1.82 | .0106 | .0202 | .0165 | .0037 | 0.58 | .0285 | .0006 | .4043 | 3.2 |
| - | 1894  | - | - | .30 | 6.98  | 1.81 | .0063 | .0199 | .0162 | .0037 | 0.66 | .0183 | .0007 | .4029 | 3.1 |
| - | 1895  | - | - | .35 | 7.43  | 2.15 | .0054 | .0245 | .0189 | .0055 | 0.69 | .0221 | .0004 | .4658 | 3.3 |

\* June to December.

NOTE to analyses of 1895: Odor, vegetable, frequently becoming stronger and sometimes unpleasant on heating. — The samples were collected from the pump well at the pumping station. For monthly record of height of water in this pond, see page 135.

## CAMBRIDGE.

*Microscopical Examination of Water from Fresh Pond, Cambridge.*

[Number of organisms per cubic centimeter.]

|                               | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|-------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                               | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .     | 3     | 6     | 6     | 3     | 6     | 7     | 10    | 8     | 4     | 3     | 6     | 3     |
| Number of sample, . . .       | 13584 | 13753 | 13918 | 14079 | 14244 | 14424 | 14687 | 14769 | 14945 | 15296 | 15474 | 15659 |
| PLANTS.                       |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .             | 834   | 423   | 69    | 72    | 1,227 | 1,321 | 130   | 146   | 15    | 16    | 580   | 532   |
| Asterionella, . . .           | 500   | 256   | 19    | 20    | 264   | 0     | 0     | 8     | 0     | 0     | 83    | 284   |
| Cyclotella, . . .             | 2     | 7     | 3     | 5     | 56    | 236   | 60    | 52    | 0     | 6     | 2     | 0     |
| Cymbella, . . .               | 0     | 0     | 0     | 0     | 0     | 352   | 0     | 0     | 0     | 0     | 0     | 0     |
| Diatoma, . . .                | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 5     | 0     | 0     | 0     |
| Fragilaria, . . .             | 20    | 0     | 0     | 0     | 7     | 0     | 0     | 4     | 0     | 0     | 0     | 2     |
| Melosira, . . .               | 61    | 0     | 0     | 30    | 600   | 0     | 18    | 32    | 5     | 0     | 432   | 50    |
| Navicula, . . .               | 0     | 0     | 0     | 0     | 1     | 1     | 0     | 0     | 0     | 4     | 0     | 0     |
| Stephanodiscus, . . .         | 72    | 22    | 19    | 8     | 76    | 0     | 0     | 0     | 3     | 0     | 0     | 196   |
| Surirella, . . .              | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 52    | 0     |
| Synedra, . . .                | 11    | 10    | 2     | 3     | 3     | 8     | 0     | 41    | 1     | 6     | 0     | 0     |
| Tabellaria, . . .             | 168   | 128   | 26    | 5     | 160   | 724   | 52    | 9     | 1     | 0     | 11    | 0     |
| Jyanophyceæ, . . .            | 3     | 0     | 0     | 0     | 0     | 18    | 1,828 | 295   | 312   | 146   | 2     | 0     |
| Anabæna, . . .                | 0     | 0     | 0     | 0     | 0     | 0     | 196   | 0     | 0     | 2     | 0     | 0     |
| Cilathrocystis, . . .         | 0     | 0     | 0     | 0     | 0     | 0     | 32    | 0     | 0     | 12    | 1     | 0     |
| Microcystis, . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 1,600 | 19    | 152   | 132   | 1     | 0     |
| Oscillaria, . . .             | 3     | 0     | 0     | 0     | 0     | 18    | 0     | 276   | 160   | 0     | 0     | 0     |
| Algæ, . . .                   | 8     | 2     | 8     | 8     | 4     | 6     | 81    | 14    | 60    | 4     | 3     | 0     |
| Closterium, . . .             | 1     | 2     | 6     | 3     | 4     | 0     | 5     | 0     | 0     | 0     | 0     | 0     |
| Gizocapsa, . . .              | 0     | 0     | 0     | 0     | 0     | 0     | 52    | 0     | 0     | 2     | 0     | 0     |
| Protococcus, . . .            | 4     | 0     | 0     | 1     | 0     | 0     | 21    | 5     | 55    | 0     | 0     | 0     |
| Raphidium, . . .              | 0     | 0     | 0     | 2     | 0     | 0     | 2     | 3     | 1     | 2     | 0     | 0     |
| Scenedesmus, . . .            | 1     | 0     | 0     | 0     | 0     | 4     | 1     | 0     | 1     | 0     | 0     | 0     |
| Staurostrum, . . .            | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 6     | 3     | 0     | 1     | 0     |
| ungi, Crenothrix, . . .       | 3     | 0     | 1     | 12    | 1     | 0     | 5     | 0     | 1     | 4     | 0     | 0     |
| ANIMALS.                      |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . .              | 1     | 5     | 13    | 129   | 15    | 2     | 9     | 8     | 10    | 6     | 7     | 0     |
| Ceratum, . . .                | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 3     | 4     | 0     | 0     |
| Ciliated infusorian, . . .    | 0     | 0     | 0     | 124   | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, . . .        | 0     | 1     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 1     | 0     |
| Euglena, . . .                | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 1     | 0     |
| Peridinium, . . .             | 0     | 0     | 0     | 0     | 2     | 0     | 6     | 0     | 0     | 2     | 0     | 0     |
| Trachelomonas, . . .          | 1     | 4     | 13    | 5     | 12    | 0     | 3     | 8     | 7     | 0     | 5     | 0     |
| miscellaneous, Zoöglæa, . . . | 0     | 0     | 0     | 0     | 12    | 0     | 0     | 4     | 55    | 300   | 0     | 0     |
| TOTAL, . . .                  | 847   | 430   | 89    | 219   | 1,259 | 1,347 | 2,058 | 467   | 453   | 476   | 592   | 532   |

## CAMBRIDGE.

*Microscopical Examination of Water from Stony Brook Storage Reservoir,  
Waltham.*

[Number of organisms per cubic centimeter.]

|                           | 1895. |       |       |       |       |       |       |       |       |       |       |  |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--|
|                           | Jan.  | Feb.  | Mar.  | Apr.  | May   | June. | July. | Aug.  | Oct.  | Nov.  | Dec.  |  |
| amination, . . . . .      | 8     | 7     | 6     | 4     | 7     | 5     | 10    | 10    | 3     | 7     | 4     |  |
| of sample, . . . . .      | 13608 | 13767 | 13921 | 14084 | 14245 | 14414 | 14592 | 14789 | 15302 | 15481 | 15664 |  |
| PLANTS.                   |       |       |       |       |       |       |       |       |       |       |       |  |
| diaceæ, . . . . .         | 1     | 13    | 2     | 6     | 211   | 96    | 4,792 | 817   | 290   | 18    | 54    |  |
| donella, . . . . .        | 0     | 0     | 0     | 0     | 0     | 1     | 396   | 700   | 24    | 9     | 1     |  |
| stella, . . . . .         | 0     | 0     | 0     | 0     | 0     | 9     | 1,020 | 44    | 0     | 0     | 0     |  |
| oma, . . . . .            | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 4     | 2     |  |
| laria, . . . . .          | 0     | 0     | 0     | 0     | 0     | 5     | 0     | 0     | 0     | 0     | 10    |  |
| dra, . . . . .            | 1     | 13    | 2     | 2     | 200   | 2     | 56    | 34    | 0     | 2     | 15    |  |
| llaria, . . . . .         | 0     | 0     | 0     | 3     | 11    | 79    | 3,320 | 39    | 176   | 3     | 26    |  |
| phyceæ, . . . . .         |       |       |       |       |       |       |       |       |       |       |       |  |
| monas, . . . . .          | 0     | 0     | 0     | 0     | 0     | 0     | 136   | 0     | 3     | 0     | 0     |  |
| rocystis, . . . . .       | 0     | 0     | 0     | 0     | 0     | 0     | 3     | 0     | 3     | 0     | 0     |  |
| sphærium, . . . . .       | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 8     | 0     | 0     |  |
| unopodia, . . . . .       | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 6     | 0     | 0     | 0     |  |
| . . . . .                 | 1     | 0     | 0     | 0     | 9     | 22    | 29    | 5     | 1     | 0     | 0     |  |
| iccoccus, . . . . .       | 0     | 0     | 0     | 0     | 0     | 22    | 28    | 0     | 0     | 0     | 0     |  |
| idium, . . . . .          | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 5     | 1     | 0     | 0     |  |
| pores, . . . . .          | 1     | 0     | 0     | 0     | 9     | 0     | 0     | 0     | 0     | 0     | 0     |  |
| Crenothrix, . . . . .     | 0     | 3     | 1     | 5     | 19    | 0     | 0     | 0     | 1     | 124   | 4     |  |
| ANIMALS.                  |       |       |       |       |       |       |       |       |       |       |       |  |
| ria, . . . . .            | 8     | 0     | 0     | 10    | 16    | 558   | 1     | 8     | 4     | 5     | 0     |  |
| bryon, . . . . .          | 0     | 0     | 0     | 8     | 0     | 292   | 0     | 0     | 0     | 0     | 0     |  |
| bryon cases, . . . . .    | 0     | 0     | 0     | 0     | 16    | 258   | 0     | 7     | 0     | 0     | 0     |  |
| monas, . . . . .          | 0     | 0     | 0     | 0     | 0     | 8     | 0     | 0     | 0     | 1     | 0     |  |
| tinium, . . . . .         | 8     | 0     | 0     | 2     | 0     | 0     | 1     | 1     | 0     | 1     | 0     |  |
| belomonas, . . . . .      | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 3     | 0     |  |
| S, . . . . .              | 0     | 0     | 0     | 0     | 2     | 2     | 1     | 0     | 2     | 0     | 0     |  |
| ea, . . . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 2     | 0     | 0     |  |
| er, . . . . .             | 0     | 0     | 0     | 0     | 2     | 2     | 0     | 0     | 0     | 0     | 0     |  |
| cea, Daphnia, . . . . .   | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | .12   | 0     | 0     |  |
| zeous, Zoöglæa, . . . . . |       |       |       |       |       |       |       |       |       |       |       |  |
| L, . . . . .              | 10    | 16    | 14    | 21    | 341   | 678   | 4,962 | 836   | 222   | 147   | 58    |  |



CAMBRIDGE.

*Showing Heights of Water in Fresh Pond and in Stony Brook Storage Reservoir on the First Day of Each Month in 1895.*

[Heights are in feet above Cambridge city base.]

| FRESH POND. HIGH WATER, 16.85. |                  | STONY BROOK RESERVOIR. ROLLWAY, 81.00. |                  |
|--------------------------------|------------------|----------------------------------------|------------------|
| DATE.                          | Height of Water. | DATE.                                  | Height of Water. |
| 1895.                          |                  | 1895.                                  |                  |
| 1. . . . .                     | 18.90            | Jan. 1. . . . .                        | 80.33            |
| 1. . . . .                     | 16.35            | Feb. 1. . . . .                        | 81.16            |
| 1. . . . .                     | 15.68            | Mar. 1. . . . .                        | 80.99            |
| 11. . . . .                    | 16.67            | April 1. . . . .                       | 81.55            |
| 1. . . . .                     | 16.68            | May 1. . . . .                         | 81.41            |
| 1. . . . .                     | 17.29            | June 1. . . . .                        | 80.88            |
| 1. . . . .                     | 16.63            | July 1. . . . .                        | 79.75            |
| 1. . . . .                     | 14.74            | Aug. 1. . . . .                        | 81.23            |
| 1. . . . .                     | 12.63            | Sept. 1. . . . .                       | 81.05            |
| 1. . . . .                     | 11.59            | Oct. 1. . . . .                        | 77.33            |
| 1. . . . .                     | 12.98            | Nov 1. . . . .                         | 81.50            |
| 1. . . . .                     | 13.49            | Dec. 1. . . . .                        | 81.77            |

WATER SUPPLY OF CHELSEA.

(See *Boston, Mystic Works.*)

WATER SUPPLY OF CHESHIRE. — CHESHIRE WATER COMPANY.

*Chemical Examination of Water from the Reservoir of the Cheshire Water Company.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.<br>Sept. 21   | Slight.     | Slight.   | .03    | 9.25                    | -                 | .0016    | .0046       | .0024      | .0022      | .11       | .0280       | .0000     | .0858            | 6.6       |

Hor. faintly unpleasant, becoming distinctly vegetable on heating. — The sample was collected the reservoir at a time when the water was unusually low.

*Microscopical Examination.*

Is insignificant number of organisms was found in this sample.

## CHESTER.

## WATER SUPPLY OF CHESTER.

*Chemical Examination of Water from the Austin Brook Reservoir of  
Chester Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |
| 1895.   |                     |             |            |        |                                 |                      |          |             |            |                 |           |                |           |
| 14261   | May 8               | V. slight.  | V. slight. | .15    | 2.45                            | 1.00                 | .0008    | .0066       | .0052      | .0014           | .08       | .0030          | .0000     |
| 15280   | Oct. 1              | Slight.     | Slight.    | .15    | 3.65                            | 0.80                 | .0014    | .0188       | .0170      | .0018           | .13       | .0050          | .0000     |

Odor of the first sample, none; of the second, very faintly vegetable. — The samples were from the reservoir.

*Microscopical Examination.*

No. 14261, Diatomaceæ, *Meridion*, 9; *Navicula*, 1; *Synedra*, 56. Fungi, *Cladothrix*, 2; *Cy*  
5. Miscellaneous, *Zoëglia*, 20. Total, 93.  
No. 15280, Fungi, *Crenothrix*, 1; *Molds*, 2. Total, 3.

## WATER SUPPLY OF CHICOPEE.

*Chemical Examination of Water from Cooley Brook and the Cooley 1  
Reservoir, Chicopee.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                  |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           |
|---------|---------------------|-------------|------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|
|         |                     | Turbidity.  | Sediment.        | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates       | Nitrites. |
|         |                     |             |                  |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |
| 1895.   |                     |             |                  |        |                                 |                      |          |             |            |                 |           |                |           |
| 13730   | Jan. 29             | V. slight.  | V. slight.       | .30    | 3.80                            | 0.95                 | .0016    | .0066       | .0046      | .0020           | .11       | .0080          | .0000     |
| 14042   | Mar. 25             | V. slight.  | Slight.          | .05    | 3.05                            | 0.60                 | .0000    | .0036       | .0026      | .0010           | .11       | .0070          | .0000     |
| 14393   | May 30              | Slight.     | Cons.            | .60    | 3.70                            | 0.90                 | .0042    | .0132       | .0090      | .0042           | .15       | .0050          | .0001     |
| 14755   | July 31             | V. slight.  | Cons.,<br>brown. | .08    | 3.60                            | 0.75                 | .0000    | .0070       | .0032      | .0038           | .11       | .0100          | .0000     |
| 15305   | Oct. 1              | Slight.     | Slight.          | .23    | 4.00                            | 1.10                 | .0022    | .0040       | .0032      | .0008           | .16       | .0030          | .0000     |
| 15732   | Dec. 16             | V. slight.  | Slight.          | .30    | 4.00                            | 1.25                 | .0008    | .0082       | .0046      | .0036           | .09       | .0070          | .0000     |
| Av.     | 1895                | .....       | .....            | .26    | 3.69                            | 0.92                 | .0015    | .0071       | .0045      | .0026           | .12       | .0067          | .0000     |
| Av.     | 1894                | .....       | .....            | .58    | 4.16                            | 1.08                 | .0014    | .0091       | .0072      | .0019           | .10       | .0042          | .0000     |

NOTE to analyses of 1895: Odor, vegetable or none; in May, vegetable and unpleasant. — 1 was collected from a brook flowing into Cooley Brook reservoir from the northwest; the other from Cooley Brook Reservoir.

*Microscopical Examination.*

The average number of organisms per cubic centimeter found in these samples was 67. The number was found in May, and consisted chiefly of *Zoëglia*.

## CHICOPEE.

*Chemical Examination of Water from Morton Brook Reservoir, Chicopee.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------------------|-------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment.         | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|                     |             |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.               |             |                   |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| Jan. 29             | V. slight.  | V. slight.        | .05    | 3.75                            | 0.45                 | .0010    | .0096       | .0078      | .0018           | .13       | .0100          | .0000     | .0513            | 1.1       |
| Mar. 25             | Slight.     | Slight,<br>green. | .03    | 3.90                            | 0.65                 | .0000    | .0066       | .0048      | .0018           | .15       | .0070          | .0000     | .0539            | 0.9       |
| May 30              | V. slight.  | Cons.             | .05    | 3.45                            | 0.40                 | .0006    | .0046       | .0032      | .0014           | .13       | .0090          | .0000     | .0912            | 1.1       |
| July 31             | V. slight.  | Slight,<br>brown. | .04    | 3.80                            | 0.25                 | .0000    | .0018       | .0010      | .0008           | .11       | .0050          | .0000     | .0936            | 0.9       |
| Oct. 1              | V. slight.  | Slight.           | .05    | 3.75                            | 0.60                 | .0030    | .0040       | .0020      | .0020           | .14       | .0070          | .0000     | .0468            | 0.6       |
| Dec. 16             | V. slight.  | Cons.             | .07    | 3.90                            | 0.70                 | .0028    | .0300       | .0234      | .0016           | .10       | .0100          | .0000     | .0939            | 0.6       |
| 1895                | .....       | .....             | .05    | 3.76                            | 0.51                 | .0012    | .0095       | .0079      | .0016           | .13       | .0080          | .0000     | .0718            | 0.9       |
| 1894                | .....       | .....             | .03    | 3.76                            | 0.59                 | .0005    | .0030       | .0023      | .0007           | .12       | .0103          | .0000     | .0594            | 1.1       |

ore to analyses of 1895: Odor, vegetable or none. — The samples were collected from the reser-

*Microscopical Examination.*

The average number of organisms per cubic centimeter found in these samples was 15.

*Chemical Examination of Water from Dingle Brook Reservoir, Chicopee.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE.     |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------------------|-----------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|                     | Turbidity.      | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|                     |                 |                |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.               |                 |                |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| Jan. 22             | V. slight.      | Slight, white. | .10    | 3.90                    | 0.80              | .0032    | .0056       | .0046      | .0010      | .22       | .0120       | .0000     | .1201            | 1.3       |
| May 30              | Distinct.       | Cons., brown.  | .23    | 3.60                    | 0.90              | .0010    | .0170       | .0052      | .0118      | .27       | .0150       | .0001     | .2181            | 1.1       |
| Sept. 25            | Decided, white. | Slight.        | .38    | 4.00                    | 1.55              | .0018    | .0428       | .0200      | .0228      | .30       | .0020       | .0001     | .2902            | 1.4       |
| .....               | .....           | .....          | .24    | 4.03                    | 1.08              | .0020    | .0218       | .0099      | .0119      | .26       | .0097       | .0001     | .2095            | 1.3       |

odor, vegetable. — The first two samples were collected from faucets in Chicopee supplied from Dingle Brook, and the last sample from the storage reservoir on Dingle Brook.

*Microscopical Examination.*

The number of organisms per cubic centimeter found in these samples was as follows: No. 13701 to 14306, 506; No. 15258, 240.

## CLINTON.

## WATER SUPPLY OF CLINTON.

*ical Examination of Water from the Sources of Supply of the Clinton Water Works, Sterling.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.<br>Aug. 16    | Decided.    | Cons.     | .95    | 5.15                            | 2.70                 | .0186    | .0512       | .0476      | .0036           | .48       | .0000          | .0001     | 1.0842           | 1.3       |
| Dec. 24             | Slight.     | Slight.   | .93    | 3.80                            | 1.75                 | .0046    | .0218       | .0200      | .0018           | .14       | .0050          | .0001     | .8547            | 0.8       |
| Aug. 16             | Decided.    | Slight.   | .28    | 3.90                            | 1.85                 | .0092    | .0370       | .0354      | .0016           | .24       | .0000          | .0000     | .6396            | 0.5       |
| Dec. 24             | Slight.     | Slight.   | .50    | 2.80                            | 1.25                 | .0000    | .0136       | .0114      | .0022           | .16       | .0000          | .0000     | .5529            | 0.5       |
| Dec. 24             | Slight.     | Slight.   | .28    | 3.00                            | 0.85                 | .0002    | .0112       | .0098      | .0014           | .16       | .0120          | .0001     | .3480            | 0.9       |
| Aug. 16             | Slight.     | Slight.   | .15    | 3.30                            | 0.95                 | .0062    | .0156       | .0142      | .0014           | .26       | .0000          | .0000     | .2730            | 0.9       |
| Dec. 24             | Slight.     | Slight.   | .25    | 2.70                            | 1.30                 | .0010    | .0110       | .0090      | .0020           | .15       | .0070          | .0000     | .3434            | 0.5       |
| Dec. 24             | Slight.     | Slight.   | .20    | 2.75                            | 1.25                 | .0022    | .0204       | .0166      | .0038           | .17       | .0070          | .0000     | .3349            | 0.3       |

lor of Nos. 14850 and 15802, distinctly vegetable; of No. 14851, distinctly vegetable and unpleasant; 15803, decidedly vegetable and mouldy; of Nos. 15804 and 14852, faintly vegetable; of the last two, none. — The samples were collected as follows: No. 14850, from Fitch's Pond near the shore; 802, from Fitch's Pond at the deepest part; No. 14851, from Heywood's Pond near the shore; No. from Heywood's Pond 50 feet above the dam; No. 15804, from Spring Basin, near the gate-house; 14852, 15805 and 15806, from Lyndes Pond.

*roscopical Examination of Water from the Sources of Supply of the Clinton Water Works, Sterling.*

[Number of organisms per cubic centimeter.]

|                        | 1895. |       |       |       |       |       |       |       |
|------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
|                        | Aug.  | Dec.  | Aug.  | Dec.  | Dec.  | Aug.  | Dec.  | Dec.  |
| f examination, . . . . | 19    | 27    | 19    | 27    | 27    | 19    | 27    | 27    |
| er of sample, . . . .  | 14850 | 15802 | 14851 | 15803 | 15804 | 14852 | 15805 | 15806 |
| PLANTS.                |       |       |       |       |       |       |       |       |
| omaceæ, . . . . .      | 228   | 3     | 238   | 88    | 53    | 36    | 47    | 40    |
| sterionella, . . . . . | 10    | 2     | 140   | 7     | 12    | 6     | 7     | 0     |
| clotella, . . . . .    | 72    | 0     | 44    | 0     | 0     | 8     | 0     | 0     |
| mbella, . . . . .      | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 0     |
| stoma, . . . . .       | 0     | 0     | 0     | 0     | 2     | 3     | 0     | 0     |
| nostira, . . . . .     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     |
| ivacula, . . . . .     | 0     | 0     | 0     | 0     | 3     | 3     | 0     | 0     |
| edra, . . . . .        | 144   | 1     | 52    | 60    | 84    | 16    | 40    | 40    |
| bellaria, . . . . .    | 2     | 0     | 0     | 1     | 1     | 0     | 0     | 0     |

## COHASSET.

*Examination of Water from the Tubular Wells of the Cohasset Water Company.*

[Parts per 100,000.]

|    | APPEARANCE.      |                |        | Residue on Evaporation | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|----|------------------|----------------|--------|------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|    | Turbidity.       | Sediment.      | Color. |                        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 7  | Distinct, milky. | V. slight.     | .12    | 18.70                  | .0006    | .0026       | 2.22      | .0210       | .0002     | .0273            | 9.4       | .0480 |
| 7  | Distinct, white. | V. slight.     | .18    | 18.30                  | .0000    | .0032       | 1.90      | .0180       | .0000     | .0245            | 9.0       | .0500 |
| 6  | Decided, milky.  | None.          | .28    | 20.40                  | .0002    | .0006       | 1.83      | .0150       | .0000     | .0277            | 10.3      | .0980 |
| 13 | Distinct.        | Slight.        | .10    | 16.80                  | .0000    | .0016       | 1.84      | .0150       | .0000     | .0553            | 8.7       | .0700 |
| 8  | Distinct, milky. | None.          | .20    | 17.70                  | .0004    | .0012       | 1.91      | .0130       | .0000     | .0077            | 7.7       | .0760 |
| 5  | Distinct, milky. | Slight.        | .25    | 16.70                  | .0002    | .0018       | 1.89      | .0050       | .0000     | .0190            | 8.0       | .0720 |
| 9  | Decided, milky.  | Slight.        | .30    | 14.30                  | .0000    | .0018       | 1.70      | .0220       | .0000     | .0474            | 7.7       | .0370 |
| 7  | Distinct, milky. | Slight, rusty. | .20    | 17.10                  | .0000    | .0004       | 1.85      | .0210       | .0000     | .0000            | 8.0       | .0900 |
| 4  | Distinct, milky. | Slight, rusty. | .28    | 18.00                  | .0004    | .0008       | 1.78      | .0300       | .0001     | .0154            | 7.4       | .0780 |
| 7  | Distinct, milky. | V. slight.     | .05    | 14.40                  | .0000    | .0008       | 1.79      | .0330       | .0000     | .0125            | 7.6       | .0550 |
| 7  | Distinct, milky. | Slight, rusty. | .15    | 16.40                  | .0008    | .0010       | 1.82      | .0400       | .0000     | .0351            | 7.1       | .1150 |
| 3  | Slight, milky.   | None.          | .17    | 17.90                  | .0000    | .0020       | 2.00      | .0200       | .0000     | .0406            | 9.3       | .0380 |
| .. | .....            | .....          | .19    | 17.22                  | .0002    | .0015       | 1.89      | .0211       | .0000     | .0260            | 8.3       | .0689 |

*Averages by Years.*

|   |   |     |       |       |       |      |       |       |       |     |       |   |
|---|---|-----|-------|-------|-------|------|-------|-------|-------|-----|-------|---|
| - | - | .00 | 15.21 | .0005 | .0016 | 1.69 | .0196 | -     | -     | -   | -     | - |
| - | - | .01 | 15.20 | .0001 | .0021 | 1.50 | .0311 | .0003 | -     | -   | -     | - |
| - | - | .00 | 11.64 | .0001 | .0022 | 1.46 | .0230 | .0002 | -     | -   | -     | - |
| - | - | .00 | -     | .0000 | .0048 | 1.48 | .0150 | .0003 | -     | -   | -     | - |
| - | - | .16 | 17.14 | .0001 | .0007 | 1.64 | .0263 | .0001 | .0415 | 8.6 | .0451 | - |
| - | - | .17 | 17.94 | .0004 | .0016 | 1.77 | .0204 | .0000 | .0276 | 8.4 | .0743 | - |
| - | - | .19 | 17.22 | .0002 | .0015 | 1.89 | .0211 | .0000 | .0260 | 8.3 | .0689 | - |

\* June to December.

† January to May.

‡ February.

analyses of 1896: Odor of the second sample, earthy; of the others, none. — The samples 1 from a faucet at the pumping station while pumping.

*Microscopical Examination.*

the number of organisms per cubic centimeter found in these samples was 313, consisting of *Orenothrix*, the highest number (1,320) being found in the February sample.

## COHASSET.

*Chemical Examination of Water from a Tubular Test Well in Cohasset.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |               |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|---------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.     | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 14382   | 1895.<br>May 28     | Decided.    | Heavy, sandy. | .10    | 18.10                   | .0000    | .0010       | 3.00      | .2200       | .0006     | .0304            | 5.9       | .0040 |

Odor, none. — The sample was collected from a tubular test well located about 1,000 feet south-east of the pumping station of the Cohasset Water Company and about 500 feet south of the railroad.

*Microscopical Examination.*

No organisms.

## WATER SUPPLY OF CONCORD AND LINCOLN.

*Chemical Examination of Water from Sandy Pond, Lincoln.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 3824    | 1895.<br>Feb. 15    | V. slight.  | V. slight. | .04    | 2.60                            | 0.80                 | .0002    | .0134       | .0122      | .0012           | .32       | .0000          | .0000     | .1400            | 0.9       |
| 3963    | Mar. 11             | V. slight.  | V. slight. | .02    | 2.50                            | 0.55                 | .0084    | .0098       | .0084      | .0014           | .29       | .0060          | .0000     | .1386            | 0.8       |
| 4102    | Apr. 8              | V. slight.  | Slight.    | .05    | 3.30                            | 1.00                 | .0020    | .0120       | .0084      | .0036           | .28       | .0080          | .0000     | .1786            | 1.7       |
| 4855    | Aug. 19             | Slight.     | Slight.    | .02    | 2.15                            | 0.55                 | .0008    | .0174       | .0154      | .0020           | .27       | .0000          | .0000     | .1950            | 0.6       |
| Av.     | .....               | .....       | .....      | .03    | 2.64                            | 0.72                 | .0028    | .0131       | .0111      | .0020           | .29       | .0035          | .0000     | .1630            | 1.0       |

Odor, vegetable or none, occasionally unpleasant. — The first two samples were collected from tests in Concord supplied from the pond, and the last two from the pond.

COTTAGE CITY.

WATER SUPPLY OF COTTAGE CITY. — COTTAGE CITY WATER COMPANY.

*Chemical Examination of Water from the Springs of the Cottage City Water Company.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 1895.<br>July 7     | None.       | Slight.   | .02    | 4.06                    | .0002    | .0008       | .91       | .0080       | .0000     | .0237            | 0.5       | .0040 |

Odor, none. — The sample was collected from a faucet at the pumping station.

*Microscopical Examination.*

No organisms.

WATER SUPPLY OF DALTON FIRE DISTRICT, DALTON.

*Chemical Examination of Water from the Upper Reservoir on Egypt Brook.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |                  |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. |           |
|---------------------|-------------|------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment.        | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. | Oxygen Consumed. | Hardness. |
|                     |             |                  |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.<br>Aug. 8     | Distinct.   | Cons.,<br>rusty. | 1.70   | 5.60                    | 2.55              | .0576    | .0870       | .0336      | .0034      | .08       | .0020       | .0000     | 1.2012           | 2.3       |

Odor, distinctly vegetable and unpleasant. Iron, .2800 parts per 100,000. — The sample was collected from the outlet pipe from the bottom of the reservoir.

*Microscopical Examination*

Long, *Crenothrix*, 128.

## DEDHAM.

## WATER SUPPLY OF DEDHAM. — DEDHAM WATER COMPANY.

*Chemical Examination of Water from the Well of the Dedham Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 13831   | 1895. Feb. 18       | None.       | None.     | .01    | 9.60                    | .0040    | .0016       | .93       | .2250       | .0000     | .0585            | 4.2       | .0000 |
| 14187   | April 19            | None.       | None.     | .02    | 9.10                    | .0000    | .0012       | .78       | .1400       | .0000     | .0774            | 3.8       | .0000 |
| 14515   | June 20             | None.       | None.     | .03    | 9.50                    | .0000    | .0012       | .82       | .1650       | .0000     | .0423            | 3.6       | .0000 |
| 14880   | Aug. 21             | None.       | None.     | .02    | 11.50                   | .0000    | .0012       | .88       | .2100       | .0000     | .0156            | 3.8       | .0000 |
| 15764   | Dec. 18             | None.       | None.     | .00    | 9.90                    | .0004    | .0024       | .82       | .1440       | .0000     | .0216            | 3.9       | .6000 |
| Av.     | .....               | .....       | .....     | .02    | 9.92                    | .0009    | .0015       | .85       | .1768       | .0000     | .0431            | 3.9       | .0000 |

*Averages by Years.*

|   |       |   |   |     |       |       |       |     |       |       |       |     |       |
|---|-------|---|---|-----|-------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1887* | - | - | .00 | 10.97 | .0002 | .0012 | .97 | .2690 | -     | -     | -   | -     |
| - | 1888† | - | - | .00 | 10.38 | .0002 | .0011 | .93 | .2810 | .0000 | -     | -   | -     |
| - | 1889‡ | - | - | .00 | 9.15  | .0000 | .0020 | .93 | .1700 | .0000 | -     | -   | -     |
| - | 1892  | - | - | .01 | 10.80 | .0002 | .0054 | .93 | .2062 | .0001 | -     | 4.4 | .0108 |
| - | 1893  | - | - | .01 | 10.49 | .0014 | .0073 | .91 | .2375 | .0001 | .1209 | 4.3 | .0139 |
| - | 1894  | - | - | .01 | 10.18 | .0000 | .0017 | .86 | .2008 | .0000 | .0293 | 4.0 | .0013 |
| - | 1895  | - | - | .02 | 9.92  | .0009 | .0015 | .85 | .1768 | .0000 | .0431 | 3.9 | .0000 |

\* June to December.

† January to May.

‡ April.

NOTE to analyses of 1895: Odor, none. — The samples were collected from a faucet at the pumping station.

*Microscopical Examination.*

No organisms.

## DIGHTON AND SOMERSET.

The advice of the State Board of Health to James H. Flint and others (petitioners for incorporation as the Dighton and Somerset Water Company, relative to taking the waters of Muddy Brook and Segreganset River and their tributaries in the town of Dighton, and water from any wells in these towns) may be found on pages 18-20 of this volume. Analyses of samples from various sources investigated are given below.



DIGHTON AND SOMERSET.

*Chemical Examination of Water from Muddy Cove Brook, Dighton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1828    | 1895.<br>Feb. 14    | V. slight.  | V. slight. | 1.20   | 5.20                    | 1.95              | .0002    | .0206       | .0168      | .0038      | .57       | .0000       | .0000     | 1.1120           | 0.8       |

Odor, distinctly vegetable. — The sample was collected from an ice-pond on Muddy Cove Brook, about half a mile west of the village of Dighton.

*Microscopical Examination.*

Diatomaceæ, *Tabellaria*, 3. Infusoria, *Dinobryon* cases, 1. Total, 4.

*Chemical Examination of Water from the Segreganset River and its Tributaries, Dighton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |           | Chlorine. | NITROGEN AS |            | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------|--------|-------------------------|-------------------|----------|-------------|------------|-----------|-----------|-------------|------------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            | Nitrates. |           | Nitrites.   |            |                  |           |
|         |                     |             |                   |        |                         |                   |          | Total.      | Dissolved. |           |           |             | Suspended. |                  |           |
| 1895.   |                     |             |                   |        |                         |                   |          |             |            |           |           |             |            |                  |           |
| 29      | Feb. 14             | V. slight.  | Slight.           | 0.68   | 4.25                    | 1.25              | .0002    | .0168       | .0146      | .0022     | .51       | .0100       | .0000      | 0.6760           | 1.1       |
| 30      | Feb. 14             | V. slight.  | Cons.,<br>earthy. | 0.65   | 4.70                    | 1.45              | .0002    | .0140       | .0108      | .0032     | .56       | .0180       | .0000      | 0.6040           | 1.4       |
| 10      | Apr. 23             | V. slight.  | V. slight.        | 1.00   | 3.95                    | 2.00              | .0002    | .0200       | .0186      | .0014     | .44       | .0000       | .0000      | 1.5010           | 0.8       |
| 14      | Apr. 23             | V. slight.  | Slight.           | 1.35   | 5.00                    | 2.65              | .0006    | .0198       | .0188      | .0010     | .57       | .0100       | .0000      | 1.6432           | 1.1       |
| 17      | Feb. 14             | None.       | V. slight.        | 0.00   | 4.30                    | -                 | .0000    | .0006       | -          | -         | .60       | .0780       | .0000      | 0.0096           | 0.8       |

Odor of the first two samples, very faintly vegetable; of the third and fourth, distinctly vegetable; the last, none. — The samples were collected as follows: No. 13829 from Sunken Brook at a road about half a mile above its junction with the Segreganset River; No. 13830 from the Segreganset about two miles east of the village of North Dighton; No. 14203 from the Segreganset River about one-fourths of a mile from its mouth and just above its confluence with Pine Swamp Brook; No. 14204 from Pine Swamp Brook near its confluence with the Segreganset River; No. 13827 from a spring about half a mile north of the village of Dighton.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 13829, 12; No. 13830, 6; No. 14203, 64; No. 14204, 53; No. 13827, 0.

## DIGHTON AND SOMERSET.

*Chemical Examination of Water from Wells, Dighton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |               |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|---------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.     | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 14205   | 1895.<br>Apr. 23    | None.       | None.         | .00    | 11.30                   | .0082    | .0014       | 0.95      | .0780       | .0014     | .0512            | 3.2       | .0000 |
| 14229   | May 3               | None.       | Cons., sandy. | .00    | 13.50                   | .0000    | .0042       | 2.09      | .2500       | .0000     | .0346            | 5.3       | .0080 |

Odor, none. — The first sample was collected from a tubular well in the valley of the Segreganset River about half a mile from its confluence with the Taunton River; the last from a well in the valley of the Segreganset River a short distance below Pine Swamp Brook.

*Microscopical Examination.*

No. 14205. Diatomaceæ, *Synedra*, 1.

No. 14229. No organisms.

## WATER SUPPLY OF EASTHAMPTON.

*Chemical Examination of Water from Bassett Brook, Easthampton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on ignition. | Free.    | Albuminoid. |            |             |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Sus-pended. |           |             |           |                  |           |
| 13597   | 1895.<br>Jan. 3     | None.       | V. slight. | .03    | 5.15                    | -                 | .0000    | .0010       | -          | -           | .14       | .0030       | .0000     | .4273            | 2.9       |
| 14255   | May 7               | V. slight.  | Cons.      | .40    | 3.40                    | 1.20              | .0004    | .0106       | .0090      | .0016       | .11       | .0050       | .0000     | .3503            | 1.4       |
| 14962   | Sept. 3             | None.       | V. slight. | .20    | 4.35                    | 1.00              | .0000    | .0074       | .0062      | .0012       | .14       | .0080       | .0001     | .2579            | 1.3       |
| Av.     | .....               | .....       | .....      | .21    | 4.30                    | -                 | .0001    | .0063       | -          | -           | .13       | .0053       | .0000     | .3452            | 1.9       |

Odor, vegetable. — The samples were collected from a faucet at the pumping station.

*Microscopical Examination.*

The number of organisms per cubic centimeter found in each of these samples was as follows: No. 13597, 0; No. 14255, 199; No. 14962, 3.

EASTON.

WATER SUPPLY OF NORTH EASTON VILLAGE DISTRICT, EASTON.

*Chemical Examination of Water from the Well of the North Easton Village District.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 1895.<br>Aug. 23    | None.       | None.     | .00    | 3.50                    | .0000    | .0016       | .54       | .0170       | .0000     | .0000            | 1.3       | .0040 |

dor, none. — The sample was collected from a faucet at the pumping station.

*Microscopical Examination.*

o organisms.

## EDGARTOWN.

The advice of the State Board of Health to Joseph K. Nye, relative to taking the water of certain springs in Edgartown for a public water supply for that town, may be found on page 20 of this volume. Analyses of samples from Lily Pond and from tubular test wells in Edgartown are given in the following tables.

*Chemical Examination of Water from Lily Pond, Edgartown.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |           | Chlorine. | NITROGEN AS |            | Oxygen Consumed. | Hardness. |
|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|-----------|-----------|-------------|------------|------------------|-----------|
|                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            | Nitrates. |           | Nitrites.   |            |                  |           |
|                     |             |           |        |                         |                   |          | Total.      | Dissolved. |           |           |             | Suspended. |                  |           |
| 1895.<br>Mar. 23    | Distinct.   | Cons.     | .40    | 4.95                    | 1.85              | .0000    | .0116       | .0058      | .0058     | 1.29      | .0030       | .0000      | .3871            | 0.6       |

dor, none; becoming faintly vegetable on heating. — The sample was collected from the outlet of Lily Pond which is situated northwest of the village.

*Microscopical Examination.*

total number of organisms per cubic centimeter, 160.

**EDGARTOWN.***Chemical Examination of Water from Tubular Test Wells, Edgartown.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 14369   | 1895.<br>May 27     | None.       | None.      | .03    | 7.80                    | .0030    | .0010       | 1.32      | .1050       | .0005     | .0380            | 2.6       | .0220 |
| 15403   | Oct. 19             | Slight.     | Slight.    | .15    | 15.00                   | .0078    | .0234       | 4.40      | .1100       | .0015     | .3666            | 2.7       | .0070 |
| 15626   | Nov. 26             | V. slight.  | V. slight. | .02    | 3.10                    | .0000    | .0010       | 0.91      | .0050       | .0000     | .0234            | 0.2       | .0020 |

Odor of the first sample, none; of the second, distinct, becoming decidedly mouldy and unpleasant on heating; of the last, distinctly earthy, becoming less strong on heating. — The first and second samples were collected from a tubular well about two miles south of the village; the last sample from a tubular well at Wintucket Bottom, about two miles from the village.

*Microscopical Examination.*

No. 14369. No organisms.

No. 15403. Fungi, *Molds*, 1. Miscellaneous, *Zoöglæa*, 42. Total, 43.

No. 15626. No organisms.

**ESSEX.***Chemical Examination of Water from Chebacco Lake in Essex and Hamillon.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment. | Color. | Total.                  | Loss on ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                     |           |        |                         |                   |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |           |
| 13785   | 1895.<br>Feb. 6     | Distinct,<br>green. | Slight.   | .75    | 5.25                    | 2.10              | .0004    | .0224       | .0176      | .0048           | 1.11      | .0050       | .0000     | .7032            | 1.1       |

Odor, very faintly vegetable, becoming stronger on heating. — The sample was collected from the lake near the northerly end.

*Microscopical Examination.*

Diatomaceæ, *Asterionella*, 16. Algae, *Closterium*, 2. Infusoria, *Dinobryon*, 2; *Dinobryon casea*, 75; *Mallomonas*, 2; *Peridinium*, 14; *Synura*, 1. Total, 116.

**WATER SUPPLY OF EVERETT.**

(See Boston, Mystic Works.)

## FAIRHAVEN.

## WATER SUPPLY OF FAIRHAVEN. — FAIRHAVEN WATER COMPANY.

## Chemical Examination of Water from the Tubular Wells of the Fairhaven Water Company.

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 1895.               |             |            |        |                         |          |             |           |             |           |                  |           |       |
| Jan. 17             | None.       | None.      | .00    | 5.50                    | .0002    | .0020       | 1.05      | .1000       | .0001     | .0158            | 1.9       | .0050 |
| Feb. 23             | None.       | None.      | .02    | 4.80                    | .0000    | .0016       | 1.00      | .0730       | .0000     | .0829            | 1.7       | .0000 |
| Apr. 22             | V. slight.  | None.      | .02    | 5.10                    | .0000    | .0008       | 1.01      | .0900       | .0002     | .0829            | 1.8       | .0080 |
| June 21             | None.       | None.      | .15    | 6.15                    | .0000    | .0038       | 1.02      | .0480       | .0000     | .1732            | 1.4       | -     |
| Aug. 30             | None.       | V. slight. | .25    | 5.40                    | .0002    | .0056       | 1.05      | .0330       | .0002     | .3850            | 1.6       | .0200 |
| Oct. 31             | None.       | V. slight. | .38    | 6.20                    | .0000    | .0090       | 1.04      | .0320       | .0000     | .4953            | 1.8       | -     |
| Dec. 20             | None.       | None.      | .12    | 5.50                    | .0006    | .0068       | 0.98      | .0350       | .0000     | .1848            | 1.8       | .0050 |
| .....               | .....       | .....      | .13    | 5.52                    | .0001    | .0042       | 1.02      | .0587       | .0001     | .2028            | 1.7       | .0075 |

odor, none. On heating, Nos. 14627 and 15453 had a faintly vegetable odor. — The samples were taken from a faucet at the pumping station.

## Microscopical Examination.

No. 13573. Fungi, *Crenothrix*, 1. Miscellaneous, *Zoëglæa*, 10. Total, 11.

No. 15453. Fungi, *Crenothrix*, 5; *Molds*, 14. Miscellaneous, *Zoëglæa*, 2. Total, 21.

In the other samples no organisms were found.

## WATER SUPPLY OF FALL RIVER.

## Chemical Examination of Water from North Watuppa Lake.

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.               |             |           |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| Feb. 25             | Slight.     | Slight.   | .40    | 3.30                            | 0.95                 | .0012    | .0186       | .0162      | .0024           | .62       | .0030          | .0001     | .4700            | 0.8       |
| Apr. 23             | Slight.     | Slight.   | .23    | 3.20                            | 1.10                 | .0012    | .0230       | .0188      | .0042           | .58       | .0000          | .0000     | .4621            | 0.8       |
| May 22              | Slight.     | Slight.   | .25    | 3.70                            | 1.45                 | .0000    | .0158       | .0132      | .0026           | .57       | .0000          | .0000     | .4294            | 0.5       |
|                     |             |           |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| .....               | .....       | .....     | .29    | 3.40                            | 1.17                 | .0008    | .0191       | .0161      | .0030           | .59       | .0010          | .0000     | .4538            | 0.7       |

odor, vegetable. — The first sample was collected from a faucet in the city, the second from a faucet at the pumping station, and the last from the gate-house at the lake.

## Microscopical Examination.

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 3579, 609; No. 14202, 229; No. 14346, 228.

## FITCHBURG.

## WATER SUPPLY OF FITCHBURG.

*Chemical Examination of Water from Scott Reservoir, Fitchburg.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                     |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. |     | Hardness. |
|---------|---------------------|-------------|---------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----|-----------|
|         |                     | Turbidity.  | Sediment.           | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |     |           |
|         |                     |             |                     |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |     |           |
| 13850   | Feb. 19             | V. slight.  | Slight,<br>fibrous. | .10    | 3.35                            | 1.10                 | .0016    | .0188       | .0144      | .0044           | .26       | .0050          | .0000     | .2980            | 0.3 |           |
| 14316   | May 16              | Distinct.   | Slight.             | .15    | 2.35                            | 1.20                 | .0002    | .0162       | .0122      | .0040           | .17       | .0000          | .0000     | .2765            | 0.5 |           |
| 14876   | Aug. 20             | Decided     | Cons.,<br>green.    | .10    | 2.50                            | 1.20                 | .0002    | .0208       | .0136      | .0072           | .19       | .0000          | .0000     | .4290            | 0.5 |           |
| 15576   | Nov. 19             | Slight.     | Slight.             | .30    | 2.80                            | 1.10                 | .0008    | .0256       | .0186      | .0070           | .18       | .0030          | .0000     | .4485            | 0.3 |           |
| Av.     | .....               | .....       | .....               | .16    | 2.75                            | 1.15                 | .0007    | .0203       | .0147      | .0056           | .20       | .0020          | .0000     | .3630            | 0.4 |           |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | .30 | 2.63 | 1.01 | .0007 | .0231 | -     | -     | .15 | .0021 | -     | -     | -   |
| - | 1888  | - | - | .11 | 2.31 | 0.79 | .0004 | .0240 | -     | -     | .13 | .0040 | .0001 | -     | -   |
| - | 1889  | - | - | .09 | 2.12 | 0.62 | .0008 | .0213 | .0162 | .0051 | .13 | .0030 | .0001 | -     | -   |
| - | 1890  | - | - | .10 | 2.54 | 1.02 | .0010 | .0217 | .0152 | .0065 | .13 | .0059 | .0001 | -     | 0.9 |
| - | 1891  | - | - | .13 | 2.55 | 1.05 | .0007 | .0146 | .0110 | .0036 | .14 | .0082 | .0000 | -     | 0.6 |
| - | 1892  | - | - | .13 | 2.78 | 1.16 | .0005 | .0261 | .0198 | .0063 | .18 | .0089 | .0000 | -     | 0.5 |
| - | 1893  | - | - | .10 | 2.68 | 1.30 | .0001 | .0233 | .0162 | .0071 | .17 | .0033 | .0000 | .2870 | 0.4 |
| - | 1894  | - | - | .14 | 2.54 | 1.01 | .0007 | .0191 | .0143 | .0048 | .18 | .0018 | .0001 | .2785 | 0.2 |
| - | 1895  | - | - | .16 | 2.75 | 1.15 | .0007 | .0203 | .0147 | .0056 | .20 | .0020 | .0000 | .3630 | 0.4 |

\* June to December.

NOTE to analyses of 1895: Odor, vegetable, and occasionally also unpleasant or mouldy. — The samples were collected from the reservoir. The heights of water in this reservoir on dates when samples of water were collected for analysis were as follows: February 19, 25 feet; May 16, 38 feet; August 20, 21 feet; November 19, 25 feet.

## FITCHBURG.

*Microscopical Examination of Water from Scott Reservoir, Fitchburg.*

[Number of organisms per cubic centimeter.]

|                           | 1895. |       |       |       |
|---------------------------|-------|-------|-------|-------|
|                           | Feb.  | May.  | Aug.  | Nov.  |
| amination, . . . . .      | 20    | 17    | 21    | 20    |
| f sample, . . . . .       | 13850 | 14316 | 14876 | 15576 |
| <b>PLANTS.</b>            |       |       |       |       |
| aceae, . . . . .          | 0     | 493   | 8,557 | 755   |
| lonella, . . . . .        | 0     | 76    | 4     | 4     |
| neis, . . . . .           | 0     | 0     | 0     | 4     |
| tella, . . . . .          | 0     | 0     | 3     | 1     |
| ma, . . . . .             | 0     | 0     | 124   | 0     |
| ira, . . . . .            | 0     | 208   | 33    | 676   |
| ula, . . . . .            | 0     | 1     | 1     | 0     |
| ira, . . . . .            | 0     | 160   | 8,272 | 12    |
| laria, . . . . .          | 0     | 48    | 120   | 58    |
| hyceae, . . . . .         | 0     | 0     | 5     | 2     |
| coccus, . . . . .         | 0     | 0     | 0     | 2     |
| mopedia, . . . . .        | 0     | 0     | 5     | 0     |
| . . . . .                 | 0     | 14    | 76    | 40    |
| odesmus, . . . . .        | 0     | 0     | 56    | 0     |
| arium, . . . . .          | 0     | 0     | 0     | 32    |
| coccus, . . . . .         | 0     | 12    | 0     | 2     |
| idium, . . . . .          | 0     | 0     | 11    | 4     |
| desmus, . . . . .         | 0     | 1     | 0     | 2     |
| astrum, . . . . .         | 0     | 0     | 7     | 0     |
| ores, . . . . .           | 0     | 1     | 2     | 0     |
| <b>ANIMALS.</b>           |       |       |       |       |
| ia, . . . . .             | 32    | 421   | 141   | 8     |
| ryon, . . . . .           | 0     | 0     | 2     | 0     |
| ryon cases, . . . . .     | 0     | 420   | 0     | 0     |
| s, . . . . .              | 0     | 0     | 2     | 0     |
| infum, . . . . .          | 32    | 1     | 136   | 8     |
| selomonas, . . . . .      | 0     | 0     | 1     | 0     |
| h, . . . . .              | 1     | 7     | 2     | 4     |
| na, . . . . .             | 0     | 4     | 1     | 0     |
| rthra, . . . . .          | 1     | 1     | 0     | 0     |
| tr, . . . . .             | 0     | 2     | 0     | 4     |
| thra, . . . . .           | 0     | 0     | 1     | 0     |
| sons, Zoöglans, . . . . . | 0     | 0     | 24    | 44    |
| h, . . . . .              | 33    | 985   | 8,805 | 853   |

**FITCHBURG.***Chemical Examination of Water from Meeting-house Pond, Westminster.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.   |                     |             |            |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 13676   | Jan. 15             | V. slight.  | V. slight. | .10    | 2.50                    | 0.85              | .0018    | .0150       | .0140      | .0010      | .24       | .0060       | .0000     | .2251            | 0.8       |
| 14026   | Mar. 20             | V. slight.  | Cons.      | .05    | 2.40                    | 0.85              | .0026    | .0140       | .0126      | .0014      | .20       | .0030       | .0000     | .2172            | 0.9       |
| 14315   | May 16              | Slight.     | Slight.    | .10    | 2.60                    | 0.95              | .0012    | .0140       | .0120      | .0020      | .14       | .0000       | .0000     | .2291            | 0.9       |
| 14668   | July 22             | Slight.     | Slight.    | .10    | 2.50                    | 0.80              | .0000    | .0144       | .0130      | .0014      | .18       | .0000       | .0000     | .2250            | 0.6       |
| 15193   | Sept. 16            | Slight.     | Slight.    | .08    | 2.30                    | 0.80              | .0000    | .0172       | .0154      | .0018      | .19       | .0000       | .0000     | .2301            | 0.6       |
| 15577   | Nov. 19             | None.       | V. slight. | .15    | 3.35                    | 1.30              | .0014    | .0118       | .0108      | .0010      | .24       | .0070       | .0000     | .3346            | 1.1       |
| Av.     | .....               | ...         | .....      | .10    | 2.61                    | 0.92              | .0012    | .0144       | .0130      | .0014      | .20       | .0027       | .0000     | .3268            | 0.8       |

*Averages by Years.*

|   |      |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1893 | - | - | .07 | 2.37 | 0.88 | .0009 | .0137 | .0113 | .0024 | .17 | .0023 | .0000 | .2304 | 0.6 |
| - | 1894 | - | - | .07 | 2.38 | 0.86 | .0011 | .0149 | .0125 | .0024 | .18 | .0026 | .0000 | .2162 | 0.6 |
| - | 1895 | - | - | .10 | 2.61 | 0.92 | .0012 | .0144 | .0130 | .0014 | .20 | .0027 | .0000 | .3268 | 0.8 |

NOTE to analyses of 1895: Odor, generally faintly vegetable. — The samples were collected from the pond as follows: The first sample near the shore north of the overflow; the second, just below dam; the remaining samples from the gate-house.

*Microscopical Examination of Water from Meeting-house Pond, Westminster.*

[Number of organisms per cubic centimeter.]

|                               | 1895. |       |       |       |       |       |
|-------------------------------|-------|-------|-------|-------|-------|-------|
|                               | Jan.  | Mar.  | May.  | July. | Sept. | Nov.  |
| Day of examination, . . . . . | 17    | 21    | 17    | 24    | 19    | 20    |
| Number of sample, . . . . .   | 13676 | 14026 | 14315 | 14668 | 15193 | 15577 |
| <b>PLANTS.</b>                |       |       |       |       |       |       |
| Diatomaceæ, . . . . .         | 2     | 10    | 58    | 52    | 12    | 0     |
| Cyclotella, . . . . .         | 0     | 0     | 0     | 14    | 1     | 0     |
| Fragilaria, . . . . .         | 0     | 0     | 0     | 13    | 0     | 0     |
| Synedra, . . . . .            | 2     | 7     | 40    | 19    | 7     | 0     |
| Tabellaria, . . . . .         | 0     | 3     | 19    | 6     | 4     | 0     |



## FITCHBURG.

*Microscopical Examination of Water from Meeting-house Pond, Westminster —*  
Concluded.

[Number of organisms per cubic centimeter.]

|                                   | 1893. |      |      |       |       |      |
|-----------------------------------|-------|------|------|-------|-------|------|
|                                   | Jan.  | Mar. | May. | July. | Sept. | Nov. |
| <b>PLANTS — Con.</b>              |       |      |      |       |       |      |
| Jeanophyceæ, . . . . .            | 0     | 0    | 0    | 1     | 54    | 32   |
| Merismopodia, . . . . .           | 0     | 0    | 0    | 0     | 32    | 0    |
| Microcystis, . . . . .            | 0     | 0    | 0    | 1     | 22    | 0    |
| Ocellularia, . . . . .            | 0     | 0    | 0    | 0     | 0     | 32   |
| Algae, . . . . .                  | 8     | 0    | 75   | 33    | 78    | 0    |
| Arthrodesmus, . . . . .           | 0     | 0    | 2    | 1     | 0     | 0    |
| Glosocapsa, . . . . .             | 0     | 0    | 0    | 0     | 10    | 0    |
| Protooccus, . . . . .             | 8     | 0    | 73   | 15    | 27    | 0    |
| Eaphidium, . . . . .              | 0     | 0    | 0    | 17    | 38    | 0    |
| Staurogenia, . . . . .            | 0     | 0    | 0    | 0     | 3     | 0    |
| Fungi, Crenothrix, . . . . .      | pr.   | 1    | 0    | 0     | 0     | 0    |
| <b>ANIMALS.</b>                   |       |      |      |       |       |      |
| Infusoria, . . . . .              | 1     | 334  | 318  | 4     | 24    | 0    |
| Dinobryon, . . . . .              | 0     | 168  | 0    | 0     | 0     | 0    |
| Dinobryon cases, . . . . .        | 1     | 0    | 312  | 0     | 24    | 0    |
| Mallomonas, . . . . .             | pr.   | 0    | 1    | 0     | 0     | 0    |
| Peridinium, . . . . .             | pr.   | 0    | 4    | 8     | 0     | 0    |
| Trachelomonas, . . . . .          | 0     | 216  | 1    | 0     | 0     | 0    |
| Vermes, Anurea, . . . . .         | 0     | 0    | 1    | 1     | 0     | 1    |
| Miscellaneous, Zoöglas, . . . . . | 0     | 0    | 60   | 0     | 0     | 0    |
| TOTAL, . . . . .                  | 11    | 395  | 513  | 90    | 168   | 33   |

**WATER SUPPLY OF FOXBOROUGH WATER SUPPLY DISTRICT,**  
**FOXBOROUGH.***Chemical Examination of Water from the Tubular Wells of the Foxborough Water*  
*Supply District.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------------------|-------------|-----------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albu- minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 1893.<br>July 8     | None.       | None.     | .00    | 3.20                    | .0000    | .0002         | .36       | .0400       | .0000     | .0000            | 0.8       | .0000 |

Odor, none. — The sample was collected from a faucet at the pumping station while pumping.

*Microscopical Examination.*

No organisms.

## FRAMINGHAM.

## WATER SUPPLY OF FRAMINGHAM. — FRAMINGHAM WATER COMPANY.

*Chemical Examination of Water from the Filter-gallery of the Framingham Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albominal. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1895.</b>        |             |           |        |                         |          |            |           |             |           |                  |           |       |
| 13872   | Feb. 20             | None.       | None.     | .03    | 7.40                    | .0042    | .0044      | .88       | .0320       | .0000     | .0608            | 3.1       | .0210 |
| 14347   | May 22              | V. slight.  | Cons.     | .02    | 7.20                    | .0000    | .0072      | .98       | .0070       | .0000     | .0874            | 3.0       | .0020 |
| 14860   | Aug. 19             | Slight.     | Slight.   | .08    | 7.40                    | .0026    | .0038      | .91       | .0330       | .0001     | .0702            | 2.7       | .0250 |
| 15614   | Nov. 26             | None.       | None.     | .04    | 7.30                    | .0014    | .0044      | .92       | .0200       | .0001     | .0468            | 3.2       | .0040 |
| Av.     | .....               | .....       | .....     | .04    | 7.32                    | .0020    | .0049      | .92       | .0230       | .0000     | .0663            | 3.0       | .0130 |

*Averages by Years.*

|   |       |   |   |     |      |       |       |     |       |       |       |     |       |
|---|-------|---|---|-----|------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1887* | - | - | .08 | 5.82 | .0031 | .0124 | .43 | .0123 | -     | -     | -   | -     |
| - | 1888  | - | - | .10 | 5.81 | .0027 | .0081 | .44 | .0308 | .0004 | -     | -   | -     |
| - | 1889  | - | - | .00 | 6.18 | .0031 | .0050 | .56 | .0366 | .0002 | -     | -   | -     |
| - | 1890  | - | - | .00 | 7.09 | .0020 | .0039 | .65 | .0631 | .0001 | -     | 3.0 | -     |
| - | 1891  | - | - | .00 | 6.25 | .0023 | .0035 | .63 | .0707 | .0001 | -     | 2.8 | -     |
| - | 1892† | - | - | .13 | 5.43 | .0061 | .0081 | .39 | .0225 | .0018 | -     | 2.6 | -     |
| - | 1893  | - | - | .04 | 6.07 | .0026 | .0033 | .62 | .0460 | .0001 | .1104 | 2.6 | .0099 |
| - | 1894  | - | - | .03 | 6.75 | .0025 | .0043 | .79 | .0515 | .0001 | .0796 | 2.8 | .0272 |
| - | 1895  | - | - | .04 | 7.32 | .0020 | .0049 | .92 | .0230 | .0000 | .0663 | 3.0 | .0130 |

\* June to November.

† Two samples in October.

NOTE to analyses of 1895: Odor of the second sample, unpleasant; of the others, none. — The samples were collected from the filter-gallery.

*Chemical Examination of Water from a Faucet in South Framingham, supplied from the Works of the Framingham Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albominal. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1895.</b>        |             |            |        |                         |          |            |           |             |           |                  |           |       |
| 13873   | Feb. 20             | Slight.     | Slight.    | .03    | 7.20                    | .0000    | .0054      | .87       | .0150       | .0000     | .0640            | 3.1       | .0300 |
| 14348   | May 22              | Slight.     | None.      | .18    | 7.90                    | .0012    | .0022      | .94       | .0000       | .0000     | .0479            | 2.9       | .0700 |
|         |                     | milky.      |            |        |                         |          |            |           |             |           |                  |           |       |
| 14861   | Aug. 19             | Distinct.   | Slight.    | .50    | 6.60                    | .0002    | .0024      | .91       | .0020       | .0001     | .0780            | 2.9       | .1400 |
|         |                     | rusty.      |            |        |                         |          |            |           |             |           |                  |           |       |
| 15615   | Nov. 26             | Distinct.   | V. slight. | .28    | 6.10                    | .0000    | .0034      | .90       | .0030       | .0001     | .0507            | 3.0       | .0370 |
|         |                     | milky.      |            |        |                         |          |            |           |             |           |                  |           |       |
| Av.     | .....               | .....       | .....      | .25    | 6.95                    | .0003    | .0033      | .90       | .0050       | .0000     | .0601            | 3.0       | .0692 |

Odor of the first sample, none, becoming very faintly vegetable on heating; of the second, distinctly unpleasant, disappearing on heating; of the third, decidedly tarry; of the last, none, becoming faintly tarry on heating.

## FRAMINGHAM.

*Chemical Examination of Water from the Underdrain beneath the Sewers at Framingham.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |                 |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------------------|-------------|-----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|                     | Turbidity.  | Sediment.       | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 1895.               |             |                 |        |                         |          |             |           |             |           |                  |           |       |
| Jan. 14             | Slight.     | Cons., flocc.   | .00    | 18.70                   | .0640    | .0190       | 2.20      | .3500       | .0018     | .0809            | 7.0       | .0470 |
| Feb. 14             | Slight.     | Cons.           | .00    | 19.20                   | .0560    | .0180       | 2.00      | .5500       | .0019     | .0592            | 7.3       | .0170 |
| Mar. 19             | Slight.     | Cons., white.   | .02    | 19.50                   | .0760    | .0070       | 1.90      | .4350       | .0018     | .0853            | 7.9       | .0340 |
| June 14             | Slight.     | Cons., rusty.   | .05    | 21.00                   | .0440    | .0090       | 2.40      | .4100       | .0020     | .0679            | 7.9       | .0630 |
| July 15             | Slight.     | Slight, yellow. | .02    | 22.70                   | .0320    | .0080       | 2.40      | .5000       | .0020     | .0936            | 7.6       | .0150 |
| July 22             | Slight.     | Slight.         | .02    | 20.70                   | .0320    | .0056       | 2.25      | .4000       | .0030     | .0412            | 7.4       | .0120 |
| Aug. 12             | None.       | Slight, rusty.  | .02    | 23.50                   | .0480    | .0040       | 2.60      | .4050       | .0021     | .1014            | 7.9       | .0300 |
| Sept. 17            | Slight.     | Slight.         | .02    | 19.90                   | .0416    | .0028       | 2.20      | .4350       | .0040     | .0796            | 6.9       | .0240 |
| Oct. 16             | Distinct.   | Cons., brown.   | .01    | 21.70                   | .0480    | .0040       | 2.50      | .4600       | .0010     | .1030            | 8.3       | .1080 |
| Nov. 12             | Slight.     | Slight.         | .08    | 22.50                   | .0440    | .0104       | 2.50      | .3650       | .0025     | .1833            | 8.0       | .0350 |
| Dec. 10             | Distinct.   | Slight.         | .09    | 21.50                   | .0480    | .0050       | 2.30      | .3250       | .0030     | .0858            | 8.6       | .0350 |
| .....               | .....       | .....           | .03    | 20.92                   | .0502    | .0056       | 2.29      | .4995       | .0023     | .0920            | 7.7       | .0366 |

*Averages by Years.*

|       |   |   |     |       |       |       |      |       |       |       |     |       |
|-------|---|---|-----|-------|-------|-------|------|-------|-------|-------|-----|-------|
| 1889† | - | - | .00 | 19.70 | .0800 | .0080 | 3.73 | .4750 | .0045 | -     | 6.6 | -     |
| 1890  | - | - | .01 | 19.71 | .0824 | .0073 | 3.51 | .5335 | .0026 | -     | 8.4 | -     |
| 1891  | - | - | .01 | 20.44 | .1029 | .0045 | 3.51 | .5333 | .0019 | -     | 8.0 | -     |
| 1892  | - | - | .01 | 19.32 | .0805 | .0042 | 3.99 | .6067 | .0018 | -     | 8.0 | -     |
| 1893  | - | - | .02 | 20.75 | .0829 | .0039 | 3.84 | .6282 | .0014 | .0645 | 7.4 | -     |
| 1894  | - | - | .00 | 22.24 | .0620 | .0033 | 3.61 | .5315 | .0028 | .0850 | 7.1 | -     |
| 1895  | - | - | .03 | 20.92 | .0502 | .0086 | 2.29 | .4995 | .0023 | .0920 | 7.7 | .0366 |

Where more than one sample was collected in a month the mean analysis for that month has been in making the average.

October.

forms to analyses of 1895: Odor, frequently faintly earthy or musty, often none; on heating, times unpleasant or disagreeable. — The samples were collected from the underdrain at its outlet, the exception of No. 15516, which was collected from a manhole.

The analysis of 1889 was made before sewage was admitted to the sewers. Several of the analyses in 1890 and those of the years 1891 to 1894 inclusive were made by the city of Boston.

**FRAMINGHAM.***Microscopical Examination of Water from the Underdrain beneath the Sewers at Framingham.*

[Number of organisms per cubic centimeter.]

|                                 | 1895. |       |       |       |       |       |       |       |        |       |       |  |
|---------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------|-------|-------|--|
|                                 | Jan.  | Feb.  | Mar.  | June. | July. | July. | Aug.  | Sept. | Oct.   | Nov.  | Dec.  |  |
| Day of examination, . . . .     | 15    | 15    | 20    | 18    | 16    | 24    | 13    | 19    | 17     | 13    | 12    |  |
| Number of sample, . . . .       | 13654 | 13819 | 13996 | 14474 | 14616 | 14670 | 14800 | 15202 | 15383  | 15516 | 15719 |  |
| PLANTS.                         |       |       |       |       |       |       |       |       |        |       |       |  |
| Fungi, Crenothrix, . . . .      | 3,280 | 1,776 | 1,680 | 640   | 720   | 156   | 440   | 13    | 36,800 | 296   | 880   |  |
| Miscellaneous, Zoöglæa, . . . . | 0     | 0     | 161   | 0     | 0     | 0     | 0     | 0     | 0      | 24    | 0     |  |
| TOTAL, . . . . .                | 3,280 | 1,776 | 1,841 | 640   | 720   | 156   | 440   | 13    | 36,800 | 320   | 880   |  |

**WATER SUPPLY OF FRANKLIN. — FRANKLIN WATER COMPANY.***Chemical Examination of Water from the Wells of the Franklin Water Company.*

[Parts per 100,000.]

| Number.  | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|----------|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|          |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 13856    | 1895.<br>Feb. 29    | None.       | V. slight. | .63    | 7.85                    | .0004    | .0094       | .72       | .1200       | .0000     | .4056            | 3.0       | .0325 |
| 14620    | June 21             | V. slight.  | V. slight. | .55    | 6.20                    | .0000    | .0136       | .51       | .0700       | .0002     | .5544            | 2.1       | .0200 |
| 14524    | June 21             | Slight.     | Slight.    | .60    | 5.60                    | .0000    | .0126       | .53       | .0680       | .0006     | .5097            | 2.2       | .0160 |
| 15404    | Oct. 22             | V. slight.  | Slight.    | .08    | 8.80                    | .0000    | .0026       | .96       | .2750       | .0000     | .1131            | 3.8       | .0070 |
| Av. .... |                     |             |            | .47    | 7.11                    | .0001    | .0095       | .68       | .1332       | .0002     | .3957            | 2.8       | .0189 |

Odor of the first and third samples, vegetable; of the others, none. — The first three samples were collected from faucets in the town; the last sample, from a faucet in the pumping station.

*Microscopical Examination.*

The average number of organisms per cubic centimeter found in these samples was 59.

GARDNER.

## WATER SUPPLY OF GARDNER. — GARDNER WATER COMPANY.

*Chemical Examination of Water from Crystal Lake, Gardner.*

[Parts per 100,000]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 13691   | 1895.<br>Jan. 18    | V. slight.  | V. slight. | .05    | 3.00                            | 0.85                 | .0012    | .0148       | .0136      | .0012           | .34       | .0030          | .0000     | .1608            | 1.3       |
| 14682   | July 23             | Distinct.   | Cons.      | .05    | 2.25                            | 0.00                 | .0004    | .0154       | .0114      | .0040           | .33       | .0000          | .0000     | .1275            | 1.3       |
| 15406   | Oct. 22             | V. slight.  | Slight.    | .05    | 3.00                            | 1.15                 | .0008    | .0274       | .0260      | .0014           | .34       | .0030          | .0000     | .1989            | 1.1       |
| Av.     | .....               | .....       | .....      | .05    | 2.75                            | 0.97                 | .0008    | .0192       | .0170      | .0022           | .34       | .0020          | .0000     | .1654            | 1.2       |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | .02 | 2.63 | 0.62 | .0006 | .0111 | -     | -     | .21 | .0019 | -     | -     | -   |
| - | 1888† | - | - | .01 | 2.60 | 0.62 | .0023 | .0112 | -     | -     | .22 | .0004 | .0001 | -     | -   |
| - | 1891‡ | - | - | .02 | 2.95 | 0.85 | .0007 | .0119 | .0098 | .0021 | .16 | .0073 | .0001 | -     | 0.7 |
| - | 1892§ | - | - | .02 | 2.45 | 0.65 | .0008 | .0104 | .0086 | .0018 | .27 | .0180 | .0000 | -     | 1.1 |
| - | 1893  | - | - | .05 | 2.65 | 0.82 | .0012 | .0126 | .0105 | .0021 | .27 | .0021 | .0000 | .1879 | 0.8 |
| - | 1894  | - | - | .04 | 2.75 | 0.98 | .0009 | .0111 | .0094 | .0017 | .31 | .0023 | .0000 | .1464 | 1.0 |
| - | 1895  | - | - | .05 | 2.75 | 0.97 | .0008 | .0192 | .0170 | .0022 | .34 | .0020 | .0000 | .1654 | 1.2 |

\* June to December.

† January to May.

‡ June, three samples.

§ March.

NOTE to analyses of 1895: Odor of the first and last samples, none, becoming distinctly vegetable on heating; of the second sample, distinctly vegetable, disappearing on heating. — The first and second samples were collected from faucets in the town and the last from Crystal Lake.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 13691, 36; No. 14682, 293; No. 15406, 32. The number of *Cyanophyceae* was as follows: No. 13691, 0; No. 14682, 76; No. 15406, 4.

## GLOUCESTER.

## WATER SUPPLY OF GLOUCESTER.

The works of the Gloucester Water Company were taken by the city Oct. 1, 1895.

The advice of the State Board of Health to the city of Gloucester, relative to its present and prospective sources of water supply, may be found on pages 20-23 of this volume. Analyses of samples of water collected during the investigation of the present supply and of the proposed sources of supply are given in the following tables.

*Chemical Examination of Water from Duke's Brook Storage Reservoir, Gloucester.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine | NITROGEN<br>AS |           | Oxygen Consumed | Hardness. |
|---------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|----------|----------------|-----------|-----------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |          | Nitrates.      | Nitrites. |                 |           |
|         |                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |          |                |           |                 |           |
| 1895.   |                     |             |           |        |                                 |                      |          |             |            |                 |          |                |           |                 |           |
| 13763   | Feb. 4              | V.slight.   | Slight.   | .60    | 4.35                            | 1.35                 | .0062    | .0204       | .0182      | .0022           | 1.05     | .0070          | .0000     | .5688           | 0.3       |
| 14426   | June 4              | Distinct.   | Slight.   | .30    | 3.85                            | 1.30                 | .0024    | .0188       | .0150      | .0038           | 0.97     | .0050          | .0000     | .3443           | 0.2       |
| 14771   | Aug. 6              | Distinct.   | Slight.   | .50    | 4.35                            | 1.50                 | .0000    | .0216       | .0192      | .0024           | 0.97     | .0100          | .0000     | .6408           | 0.3       |
| 14998   | Sept. 3             | Slight.     | Slight.   | .30    | 4.40                            | 2.00                 | .0018    | .0202       | .0184      | .0018           | 0.92     | .0000          | .0002     | .4290           | 0.2       |
| 15491   | Nov. 6              | None.       | V.slight. | .60    | 4.25                            | 1.75                 | .0042    | .0200       | .0158      | .0042           | 0.90     | .0050          | .0000     | .4820           | 0.2       |
| Av.     | .....               | .....       | .....     | .46    | 4.24                            | 1.58                 | .0029    | .0202       | .0173      | .0029           | 0.96     | .0054          | .0000     | .4930           | 0.3       |

Odor, vegetable; in June and November, also mouldy.—The samples were collected from the reservoir.

*Microscopical Examination of Water from Duke's Brook Storage Reservoir, Gloucester.*

[Number of organisms per cubic centimeter.]

|                                      | 1895. |       |       |       |       |
|--------------------------------------|-------|-------|-------|-------|-------|
|                                      | Feb.  | July. | Aug.  | Sept. | Nov.  |
| Day of examination, . . . . .        | 6     | 7     | 8     | 7     | 8     |
| Number of sample, . . . . .          | 13763 | 14426 | 14771 | 14998 | 15491 |
| <b>PLANTS.</b>                       |       |       |       |       |       |
| Diatomaceæ, . . . . .                | 0     | 9     | 85    | 0     | 1     |
| Cyclotella, . . . . .                | 0     | 2     | 1     | 0     | 0     |
| Synedra, . . . . .                   | 0     | 7     | 84    | 0     | 1     |
| Cyanophyceæ, Merismopedia, . . . . . | 0     | 0     | 10    | 0     | 0     |

GLOUCESTER.

Microscopical Examination of Water from Dike's Brook Storage Reservoir, Gloucester — Concluded.

[Number of organisms per cubic centimeter.]

|                                | 1895.    |            |            |           |           |
|--------------------------------|----------|------------|------------|-----------|-----------|
|                                | Feb.     | July.      | Aug.       | Sept.     | Nov.      |
| <b>PLANTS — Con.</b>           |          |            |            |           |           |
| Algae, . . . . .               | 0        | 344        | 4          | 12        | 35        |
| Coelastrum, . . . . .          | 0        | 0          | 0          | 0         | 27        |
| Protococcus, . . . . .         | 0        | 344        | 4          | 12        | 8         |
| <b>ANIMALS.</b>                |          |            |            |           |           |
| Infusoria, . . . . .           | 0        | 0          | 2          | 4         | 0         |
| Dinobryon cases, . . . . .     | 0        | 0          | 0          | 2         | 0         |
| Peridinium, . . . . .          | 0        | 0          | 0          | 1         | 0         |
| Trachelomonas, . . . . .       | 0        | 0          | 1          | 1         | 0         |
| Vorticella, . . . . .          | 0        | 0          | 1          | 0         | 0         |
| Formes, . . . . .              | 0        | 2          | 0          | 0         | 0         |
| Polyarthra, . . . . .          | 0        | 1          | 0          | 0         | 0         |
| Rotifer, . . . . .             | 0        | 1          | 0          | 0         | 0         |
| Cellaneous, Zoëglæa, . . . . . | 0        | 0          | 2          | 0         | 0         |
| <b>TOTAL, . . . . .</b>        | <b>0</b> | <b>355</b> | <b>103</b> | <b>16</b> | <b>36</b> |

Chemical Examination of Water from Wallace Pond, Gloucester.

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |               |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------------------|-------------|---------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment.     | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|                     |             |               |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.               |             |               |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| Feb. 4              | Slight.     | Slight.       | .60    | 5.55                    | 1.75              | .0034    | .0370       | .0204      | .0166      | 1.36      | .0120       | .0000     | .6162            | 1.1       |
| June 4              | Decided.    | Cons., green. | .63    | 5.15                    | 2.25              | .0008    | .0356       | .0222      | .0134      | 1.12      | .0030       | .0000     | .6027            | 0.8       |
| Aug. 6              | Decided.    | Cons., green. | .70    | 5.35                    | 2.25              | .0006    | .0452       | .0258      | .0194      | 1.15      | .0160       | .0001     | .8424            | 1.1       |
| Sept. 3             | Decided.    | Cons., green. | .60    | 5.95                    | 2.85              | .0000    | .0400       | .0230      | .0170      | 1.15      | .0000       | .0003     | .7332            | 0.5       |
| Nov. 6              | Distinct.   | Cons., green. | .45    | 5.70                    | 3.20              | .0002    | .0302       | .0232      | .0070      | 1.11      | .0050       | .0000     | .7176            | 0.3       |
|                     |             |               | .60    | 5.54                    | 2.46              | .0010    | .0376       | .0229      | .0147      | 1.18      | .0072       | .0001     | .7024            | 0.8       |

odor, distinctly vegetable and sometimes unpleasant. — The samples were collected from Wallace Pond.

## GLOUCESTER.

*Microscopical Examination of Water from Wallace Pond, Gloucester.*

[Number of organisms per cubic centimeter.]

|                                   | 1895. |       |       |        |       |
|-----------------------------------|-------|-------|-------|--------|-------|
|                                   | Feb.  | June. | Aug.  | Sept.  | Nov.  |
| Day of examination, . . . . .     | 6     | 7     | 8     | 7      | 8     |
| Number of sample, . . . . .       | 13762 | 14425 | 14770 | 14999  | 15490 |
| <b>PLANTS.</b>                    |       |       |       |        |       |
| Diatomaceæ, . . . . .             | 4     | 52    | 0     | 0      | 0     |
| Asterionella, . . . . .           | 4     | 28    | 0     | 0      | 0     |
| Synedra, . . . . .                | 0     | 7     | 0     | 0      | 0     |
| Tabellaria, . . . . .             | 0     | 7     | 0     | 0      | 0     |
| Algae, . . . . .                  | 4     | 8     | 1,064 | 17,850 | 4,000 |
| Chlorococcus, . . . . .           | 0     | 0     | 0     | 50     | 0     |
| Conferva, . . . . .               | 0     | 0     | 1,040 | 17,600 | 4,000 |
| Gloeocapsa, . . . . .             | 0     | 2     | 0     | 50     | 0     |
| Pandorina, . . . . .              | 0     | 0     | 24    | 0      | 0     |
| Raphidium, . . . . .              | 0     | 3     | 0     | 0      | 0     |
| Scenedesmus, . . . . .            | 0     | 3     | 0     | 0      | 0     |
| Zoospores, . . . . .              | 4     | 0     | 0     | 150    | 0     |
| <b>ANIMALS.</b>                   |       |       |       |        |       |
| Infusoria, . . . . .              | 173   | 500   | 228   | 700    | 13    |
| Monas, . . . . .                  | 0     | 0     | 0     | 150    | 0     |
| Paramecium, . . . . .             | 0     | 0     | 0     | 50     | 0     |
| Peridinium, . . . . .             | 172   | 500   | 228   | 450    | 0     |
| Trachelomonas, . . . . .          | 1     | 0     | 0     | 50     | 13    |
| Vermes, Rotifer, . . . . .        | 0     | 0     | 0     | 0      | 1     |
| Miscellaneous, Zoöglæa, . . . . . | 0     | 28    | 106   | 0      | 136   |
| TOTAL, . . . . .                  | 181   | 588   | 1,398 | 18,550 | 4,150 |

*Chemical Examination of Water from a Faucet at City Hall, Gloucester, supplied from the Gloucester Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13786   | 1895.<br>Feb. 6     | None.       | V. slight. | .60    | 4.25                    | 1.55              | .0006    | .0138       | .0134      | .0004      | 1.05      | .0070       | .0000     | .4977            | 0.5       |

Odor, very faintly vegetable.

*Microscopical Examination.*Algae, *Protococcus*, 30.



## GLOUCESTER.

*Chemical Examination of Water from Various Surface Water Sources in Gloucester.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 13756   | Feb. 4              | V. slight.  | V. slight. | 0.40   | 3.95                            | 1.10                 | .0000    | .0094       | .0068      | .0026           | 1.06      | .0050          | .0000     | 0.4068           | 0.5       |
| 13757   | Feb. 4              | Slight.     | Slight.    | 1.80   | 7.25                            | 3.10                 | .0042    | .0300       | .0268      | .0032           | 1.27      | .0050          | .0000     | 2.0145           | 0.6       |
| 13758   | Feb. 4              | Slight.     | Cons.      | 0.55   | 5.10                            | 1.45                 | .0022    | .0372       | .0162      | .0210           | 1.33      | .0050          | .0000     | 1.0428           | 0.6       |
| 13759   | Feb. 4              | V. slight.  | Slight.    | 2.00   | 6.55                            | 3.00                 | .0000    | .0234       | .0206      | .0028           | 1.07      | .0050          | .0000     | 2.5676           | 0.8       |
| 13760   | Feb. 4              | V. slight.  | Slight.    | 1.20   | 5.25                            | 1.80                 | .0002    | .0108       | .0090      | .0018           | 1.17      | .0070          | .0000     | 1.1850           | 0.3       |
| 13761   | Feb. 4              | V. slight.  | V. slight. | 1.40   | 5.50                            | 2.35                 | .0004    | .0178       | .0158      | .0020           | 1.03      | .0030          | .0000     | 1.6590           | 0.8       |

Odor of Nos. 13756, 13757, 13759 and 13761 faintly vegetable; of Nos. 13758 and 13760 distinctly vegetable. On heating, the odor of Nos. 13756, 13757 and 13759 was distinctly vegetable and unpleasant and of No. 13758 very disagreeable. — No. 13756 was collected from Haskell's Brook just above the dam of Haskell's Reservoir; No. 13757, from Fernwood Lake at Homan's ice-house; No. 13758, from Lily Pond Brook near the pumping station of the Gloucester Water Company; No. 13759, from Norman's Wee Brook in Magnolia Swamp, about  $\frac{1}{2}$  mile below Western Avenue; No. 13760, from a brook in Cedar Swamp near Bennett's Hill; No. 13761, from a brook in Cedar Swamp near Magnolia Avenue.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 13756, 1; No. 13757, 236; No. 13758, 363; No. 13759, 14; No. 13760, 4; No. 13761, 1.

## WATER SUPPLY OF GRAFTON. — GRAFTON WATER COMPANY.

*Chemical Examination of Water from the Filler-gallery of the Grafton Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         |                     |             |            |        |                         |          |             |           |             |           |                  |           |       |
| 14733   | 1895.<br>July 30    | None.       | V. slight. | .04    | 9.85                    | .0000    | .0014       | 1.25      | .2900       | .0000     | .0539            | 4.2       | .0250 |
| 14951   | Sept. 3             | None.       | None.      | .00    | 9.80                    | .0000    | .0014       | 1.11      | .2200       | .0002     | .0346            | 3.2       | .0030 |

Odor, none. — The first sample was collected from a faucet at the office of the water company, and the second from the pump well at the pumping station.

*Microscopical Examination.*

No. 14733. Cyanophyceæ, *Oscillaria*, 2. Infusoria, *Peridinium*, 23. Total, 30.

No. 14951. Diatomaceæ, *Synedra*, 4. Algeæ, *Scenedesmus*, 1. Infusoria, *Peridinium*, 5. Total, 10.

## GREENFIELD.

## WATER SUPPLY OF GREENFIELD.

In the early part of 1895 a pumping station was erected on the bank of Green River, in order to obtain an auxiliary supply from the river, but no water was drawn from this source for the supply of the town during the year.

The advice of the State Board of Health to the town of Greenfield, with reference to the use of Green River as a source of additional water supply for the town, may be found on pages 23 and 24 of this volume. Analyses of samples of water from this source may be found on page 382 of the annual report for 1894.

## GROTON.

The advice of the State Board of Health to the town of Groton relative to a public water supply for the town may be found on pages 24 and 25 of this volume. Analyses of samples of water collected from various sources in the town, in connection with the investigations of the Board, are given in the following tables.

*Chemical Examination of Water from Badducok Pond, Groton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |       | Oxygen Consumed. | Hardness. |
|---------|---------------------|--------------------|-------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-------|------------------|-----------|
|         |                     | Turbidity.         | Sediment.         | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           |             |       |                  |           |
|         |                     |                    |                   |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |       |                  |           |
| 13934   | 1895.<br>Mar. 2     | V. slight.         | Slight.           | .23    | 6.10                    | 1.30              | .0006    | .0174       | .0162      | .0012      | .20       | .0100       | .0001 | .4528            | 2.7       |
| 14615   | July 12             | Slight.            | Cons.             | .30    | 5.40                    | 1.60              | .0006    | .0206       | .0182      | .0024      | .19       | .0000       | .0000 | .5226            | 2.6       |
| 14762   | Aug. 3              | Distinct.          | Cons.             | .20    | 6.25                    | 1.70              | .0004    | .0200       | .0174      | .0026      | .21       | .0050       | .0000 | .5772            | 3.2       |
| 15229   | Sept. 21            | Slight.            | Slight.           | .25    | 5.90                    | 1.70              | .0012    | .0202       | .0186      | .0016      | .22       | .0020       | .0000 | .4290            | 2.3       |
| 15431   | Oct. 25             | green<br>Distinct. | green.<br>Slight. | .27    | 5.55                    | 2.65              | .0004    | .0198       | .0166      | .0032      | .20       | .0050       | .0000 | .4953            | 2.6       |

Odor, generally faintly vegetable; in July, decidedly vegetable. — The samples were collected from the pond near the surface, from 200 to 800 feet from the southerly shore.

## GROTON.

*Microscopical Examination of Water from Baddacook Pond, Groton.*

[Number of organisms per cubic centimeter.]

|                          | 1895. |       |       |       |       |
|--------------------------|-------|-------|-------|-------|-------|
|                          | Mar.  | July. | Aug.  | Sept. | Oct.  |
| ation, . . . . .         | 8     | 13    | 6     | 25    | 30    |
| ample, . . . . .         | 13934 | 14615 | 14762 | 15229 | 15431 |
| <b>PLANTS.</b>           |       |       |       |       |       |
| ess, . . . . .           | 1     | 470   | 103   | 27    | 381   |
| lla, . . . . .           | 0     | 308   | 11    | 4     | 68    |
| , . . . . .              | 0     | 145   | 88    | 1     | 100   |
| , . . . . .              | 0     | 5     | 0     | 4     | 24    |
| , . . . . .              | 0     | 1     | 0     | 0     | 5     |
| , . . . . .              | 1     | 10    | 4     | 18    | 184   |
| cess, . . . . .          | 0     | 250   | 21    | 8     | 0     |
| , . . . . .              | 0     | 6     | 0     | 0     | 0     |
| stis, . . . . .          | 0     | 4     | 0     | 0     | 0     |
| is, . . . . .            | 0     | 240   | 21    | 1     | 0     |
| , . . . . .              | 0     | 0     | 0     | 7     | 0     |
| . . . . .                | 0     | 87    | 84    | 4     | 21    |
| a, . . . . .             | 0     | 0     | 0     | 4     | 5     |
| us, . . . . .            | 0     | 81    | 72    | 0     | 14    |
| n, . . . . .             | 0     | 4     | 10    | 0     | 1     |
| nus, . . . . .           | 0     | 2     | 2     | 0     | 1     |
| othrix, . . . . .        | 3     | 0     | 0     | 0     | 0     |
| <b>ANIMALS.</b>          |       |       |       |       |       |
| , Actinophrya, . . . . . | 0     | 0     | 0     | 0     | 1     |
| . . . . .                | 0     | 1     | 0     | 1     | 49    |
| n, . . . . .             | 0     | 0     | 0     | 0     | 15    |
| n cases, . . . . .       | 0     | 0     | 0     | 1     | 32    |
| as, . . . . .            | 0     | 1     | 0     | 0     | 0     |
| m, . . . . .             | 0     | 0     | 0     | 0     | 1     |
| nonas, . . . . .         | 0     | 0     | 0     | 0     | 1     |
| , Zoögicea, . . . . .    | 0     | 0     | 0     | 28    | 80    |
| . . . . .                | 4     | 808   | 208   | 68    | 532   |

**GROTON.***Chemical Examination of Water from Martin's Pond and from the Nashua River, Groton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.   |                     |             |           |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 13935   | Mar. 2              | Decided.    | Cons.     | .75    | 9.65                    | 2.65              | .1440    | .0472       | .0368      | .0104      | .25       | .0030       | .0000     | .9971            | 4.6       |
| 14350   | May 22              | Distinct.   | Cons.     | .40    | 4.85                    | 1.70              | .0014    | .0164       | .0154      | .0010      | .40       | .0170       | .0003     | .4028            | 1.6       |

Odor of the first sample, decidedly disagreeable; of the second, distinctly vegetable. — The first sample was collected from the pond; the last, from a tap supplied with water pumped from the Nashua River.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 13935, 171; No. 14350, 326.

*Chemical Examination of Water from Cady Pond and a Spring near its Westerly Shore.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.   |                     |             |           |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 13937   | Mar. 2              | Distinct.   | Cons.     | .58    | 12.60                   | 2.20              | .0122    | .0236       | .0168      | .0068      | .18       | .0000       | .0008     | .5698            | 6.7       |
| 14024   | Mar. 20             | Slight.     | Cons.     | .80    | 9.25                    | 2.35              | .0068    | .0316       | .0266      | .0050      | .19       | .0230       | .0003     | .8785            | 4.3       |
| 13936   | Mar. 2              | V. slight.  | Slight.   | .01    | 12.50                   | 0.50              | .0000    | .0028       | .0014      | .0014      | .16       | .0070       | .0000     | .0662            | 7.9       |
| 14023   | Mar. 20             | V. slight.  | Cons.     | .18    | 13.25                   | 1.85              | .0038    | .0068       | .0058      | .0010      | .15       | .0170       | .0002     | .2449            | 7.7       |

Odor of the first two samples, distinctly vegetable and mouldy; of the others, none. — The first two samples were collected from the pond and the last two from the spring.

*Microscopical Examination.*

The average number of organisms per cubic centimeter found in these samples was 307.

## GROTON.

*Chemical Examination of Water from a Spring and a Brook in Shattuck's Meadow, about One-fourth of a Mile west of Baddacook Pond.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-----------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Alb-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 15430   | 1895.<br>Oct. 25    | Slight.     | Slight.   | .02    | 6.20                    | .0000    | .0002           | .26       | .0480       | .0000     | .1934            | 2.6       | .0010 |
| 15442   | Oct. 29             | -           | -         | .10    | -                       | -        | -               | .34       | -           | -         | -                | 2.6       | -     |

Odor of the first sample, none, becoming faintly vegetable on heating; odor of the second sample not determined. — The first sample was collected from a spring; the last, from a brook in the vicinity of the spring.

*Microscopical Examination.*

No. 15430. Diatomaceæ, *Diatoma*, 2. Algæ, *Zoospores*, 1. Fungi, *Molds*, 4. Miscellaneous, *Zoöglæa*, 9. Total, 16.

*Chemical Examination of Water from a Tubular Well at the Groton School, Groton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-----------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Alb-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 14351   | 1895.<br>May 22     | V. slight.  | Slight.   | .05    | 11.40                   | .0000    | .0000           | .20       | .0000       | .0000     | .0099            | 5.9       | .0370 |

Odor, none. — The sample was collected from a faucet in the school.

*Microscopical Examination.*

Fungi, *Crenothrix*, 572.

## HATFIELD.

The advice of the State Board of Health to the town of Hatfield, with reference to taking a water supply from Running Gutter Brook in the westerly part of the town, may be found on pages 25 and 26 of this volume. The results of an analysis of a sample of water from this brook are given on the following page.

**HATFIELD.***Chemical Examination of Water from Running Gutter Brook, Hatfield.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13826   | 1895.<br>Feb. 15    | None.       | Cons., earthy. | .08    | 3.95                    | 0.85              | .0000    | .0026       | .0012      | .0014      | .10       | .0120       | .0000     | .1000            | 1.8       |

Odor, faintly vegetable. — The sample was collected from the brook at the first road crossing above its junction with Broad Brook, and a short distance below the site of a proposed reservoir.

*Microscopical Examination.*

Diatomaceæ, Cocconeis, 1. Algae, Protococcus, 1. Total, 2.

**WATER SUPPLY OF HAVERHILL.**

In 1895 an additional supply of water was introduced into the city of Haverhill from East Meadow River in the north-easterly part of the city, and a storage reservoir was constructed upon the stream at Millvale, about half a mile from the point where it enters the Merrimack River.

The reservoir has an area of about 50 acres and a capacity of about 125,000,000 gallons. Its maximum depth at high water is 15 feet and its average depth 7 feet. It was thoroughly prepared for the storage of water by removing the soil, mud and vegetable matter from the area to be flowed.

The water from this source is pumped into the easterly end of Kenoza Lake through a 24-inch main about one mile in length, the surface of Kenoza Lake at high water being 18 feet above the high-water level of the Millvale Reservoir.

The watershed of East Meadow River tributary to the Millvale Reservoir has an area of 7.75 square miles, on which there is a very small population. There is one small pond on the watershed about 3 miles above the reservoir, and there is a considerable area of swamp in the vicinity of the river, a large portion being located within a short distance of the reservoir.

## HAVERHILL.

*Chemical Examination of Water from Crystal Lake, Haverhill.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 13899   | 1893.<br>Feb. 27    | None.       | V. slight. | .02    | 3.65                            | 1.20                 | .0016    | .0160       | .0150      | .0010           | .28       | .0030          | .0000     | .3602            | 1.7       |
| 15443   | Oct. 29             | V. slight   | V. slight. | .20    | 3.00                            | 1.25                 | .0008    | .0200       | .0168      | .0032           | .32       | .0000          | .0000     | .3604            | 1.3       |

Odor, faintly vegetable. — The first sample was collected from a faucet at the office of the Haverhill water works, and the second from the lake.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: in February, 17; in November, 121.

*Chemical Examination of Water from Kenoza Lake, Haverhill.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 13897   | 1893.<br>Feb. 27    | V. slight   | V. slight. | .10    | 4.35                            | 1.15                 | .0010    | .0184       | .0174      | .0010           | .46       | .0000          | .0000     | .2828            | 2.1       |
| 15444   | Oct. 29             | V. slight.  | V. slight. | .08    | 3.60                            | 1.20                 | .0000    | .0170       | .0156      | .0014           | .42       | .0000          | .0000     | .2262            | 1.9       |

Odor, vegetable. — The samples were collected from the lake.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: in February, 1; in October, 164.

**HAVERHILL.***Chemical Examination of Water from Lake Saltonstall, Haverhill.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13898   | 1895.<br>Feb. 27    | None.       | V. slight. | .05    | 6.00                    | 1.25              | .0068    | .0168       | .0148      | .0020      | .78       | .0030       | .0001     | .2354            | 2.7       |
| 15446   | Oct. 29             | Slight.     | Slight.    | .09    | 5.90                    | 1.75              | .0000    | .0192       | .0168      | .0024      | .76       | .0000       | .0000     | .1888            | 2.5       |

Odor, vegetable. — The samples were collected from the lake, which is also known as Plug Pond.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: in February, 7; in October, 464.

*Chemical Examination of Water from Lake Pentucket, Haverhill.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |                | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|----------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |                |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Sus-<br>pended |           |             |           |                  |           |
| 13896   | 1895.<br>Feb. 27    | None.       | V. slight. | .04    | 4.65                    | 1.05              | .0006    | .0198       | .0190      | .0008          | .49       | .0030       | .0000     | .2528            | 2.2       |
| 15445   | Oct. 29             | Slight.     | Slight.    | .07    | 3.95                    | 1.35              | .0004    | .0198       | .0176      | .0022          | .49       | .0000       | .0000     | .2418            | 1.8       |

Odor, vegetable. — The samples were collected from the lake, which is also known as Round Pond.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: in February, 2; in October, 24.



## HAVERHILL.

*Chemical Examination of Water from East Meadow River, Haverhill.*

[Parts per 100,000.]

| Number.        | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|----------------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|                |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.<br>44134 | Apr. 11             | V. slight.  | Slight.    | 1.10   | 4.45                            | 2.15                 | .0000    | .0192       | .0180      | .0012           | .30       | .0000          | .0000     | .9740            | 1.4       |
| 14739          | July 30             | V. slight.  | V. slight. | 0.40   | 5.00                            | 1.55                 | .0000    | .0118       | .0106      | .0012           | .30       | .0070          | .0000     | .9927            | 3.0       |

Odor of the first sample, very faintly vegetable; of the second, decidedly vegetable. — The first sample was collected from the river just above the point where it crosses Millville Road, about half a mile from its mouth. The second sample was collected from the river at Thompson's bridge, just above the reservoir.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows : in April, 1; in July, 44.

## WATER SUPPLY OF HINGHAM AND HULL. — HINGHAM WATER COMPANY.

*Chemical Examination of Water from Accord Pond, Hingham.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 14030   | 1893.<br>Mar. 20    | V. slight.  | Slight.    | .25    | 3.15                    | 1.35              | .0016    | .0130       | .0116      | .0014      | .70       | .0000       | .0000     | .3713            | 0.3       |
| 14312   | June 19             | Distinct.   | Slight.    | .22    | 3.15                    | 1.50              | .0000    | .0138       | .0122      | .0016      | .64       | .0180       | .0000     | .3136            | 0.2       |
| 15221   | Sept. 19            | V. slight.  | V. slight. | .12    | 4.50                    | 1.20              | .0000    | .0108       | .0094      | .0014      | .88       | .0030       | .0000     | .1911            | 0.5       |
| 15739   | Dec. 16             | V. slight.  | Slight.    | .30    | 3.20                    | 1.45              | .0016    | .0166       | .0154      | .0012      | -         | .0230       | .0000     | .3758            | 0.3       |
| Av.     | .....               | .....       | .....      | .22    | 3.50                    | 1.37              | .0008    | .0135       | .0121      | .0014      | .67       | .0110       | .0000     | .3129            | 0.3       |

Odor of the first three samples, vegetable; of the last, none. — The samples were collected from the pond.

## HINGHAM AND HULL.

*Microscopical Examination of Water from Accord Pond, Hingham.*

[Number of organisms per cubic centimeter.]

|                                  | 1895.  |       |            |           |
|----------------------------------|--------|-------|------------|-----------|
|                                  | March. | June. | September. | December. |
| Day of examination, . . . . .    | 21     | 21    | 21         | 18        |
| Number of sample, . . . . .      | 14080  | 14512 | 15221      | 15739     |
| <b>PLANTS.</b>                   |        |       |            |           |
| Diatomaceæ, . . . . .            | 31     | 34    | 37         | 43        |
| Asterionella, . . . . .          | 19     | 0     | 24         | 0         |
| Cyclotella, . . . . .            | 12     | 80    | 0          | 3         |
| Fragilaria, . . . . .            | 0      | 0     | 2          | 1         |
| Melosira, . . . . .              | 0      | 7     | 60         | 39        |
| Synedra, . . . . .               | 0      | 6     | 1          | 4         |
| Tabellaria, . . . . .            | 0      | 1     | 0          | 1         |
| Cyanophyceæ, . . . . .           | 0      | 2     | 27         | 0         |
| Anabaena, . . . . .              | 0      | 2     | 0          | 0         |
| Merismopedia, . . . . .          | 0      | 0     | 4          | 0         |
| Microcystis, . . . . .           | 0      | 0     | 23         | 0         |
| Algæ, Raphidium, . . . . .       | 0      | 0     | 8          | 0         |
| <b>ANIMALS.</b>                  |        |       |            |           |
| Rhizopoda, . . . . .             | 0      | 1     | 0          | 1         |
| Actinophrys, . . . . .           | 0      | 0     | 0          | 1         |
| Arcella, . . . . .               | 0      | 1     | 0          | 0         |
| Infusoria, . . . . .             | 428    | 18    | 0          | 2         |
| Codonella, . . . . .             | 0      | 0     | 0          | 2         |
| Dinobryon, . . . . .             | 166    | 9     | 0          | 0         |
| Dinobryon cases, . . . . .       | 256    | 0     | 0          | 0         |
| Peridinium, . . . . .            | 4      | 7     | 0          | 0         |
| Vermes, . . . . .                | 0      | 3     | 0          | 0         |
| Anura, . . . . .                 | 0      | 2     | 0          | 0         |
| Rotatorian ova, . . . . .        | 0      | 1     | 0          | 0         |
| Miscellaneous, Zoöglæ, . . . . . | 0      | 0     | 0          | 20        |
| TOTAL, . . . . .                 | 457    | 116   | 120        | 71        |

## HINGHAM AND HULL.

*Chemical Examination of Water from Fulling Mill Pond, Hingham.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|------------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.       | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                  |                |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.   |                     |                  |                |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 4031    | Mar. 20             | V. slight.       | Cons.          | .23    | 4.20                    | 1.40              | .0006    | .0088       | .0074      | .0014      | .60       | .0170       | .0000     | .2449            | 1.3       |
| 4511    | June 19             | Decided, green   | Cons., dark.   | .18    | 4.90                    | 1.40              | .0000    | .0164       | .0108      | .0056      | .78       | .0180       | .0000     | .3081            | 1.4       |
| 5222    | Sept. 19            | Distinct, green. | Slight, green. | .12    | 4.30                    | 1.25              | .0008    | .0110       | .0082      | .0028      | .71       | .0150       | .0000     | .2824            | 1.3       |
| 7777    | Dec. 18             | V. slight.       | V. slight.     | .20    | 5.30                    | 1.05              | .0030    | .0068       | .0050      | .0018      | .78       | .0170       | .0000     | .1540            | 1.3       |
| Av.     | .....               | .....            | .....          | .18    | 4.67                    | 1.27              | .0011    | .0107       | .0078      | .0020      | .72       | .0167       | .0000     | .2473            | 1.3       |

Odor, vegetable. — The samples were collected from the pond.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 14031, 15; No. 14511, 1,388, chiefly Actinophrys; No. 15222, 378; No. 15777, 8.

*Chemical Examination of Water from Tubular Test Wells in Hingham.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.     |                |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-----------------|----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.      | Sediment.      | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         |                     |                 |                |        |                         |          |             |           |             |           |                  |           |       |
| 1895.   |                     |                 |                |        |                         |          |             |           |             |           |                  |           |       |
| 14758   | Aug. 2              | Slight, milky.  | Slight, sandy. | —*     | 14.40                   | .0040    | .0012       | 1.70      | .0050       | .0000     | .0936            | 8.6       | .0700 |
| 14848   | Aug. 15             | Decided, milky. | Cons., rusty.  | .10†   | 7.50                    | .0000    | .0000       | 0.62      | .0000       | .0000     | .0702            | 3.2       | .5000 |
| 14903   | Aug. 23             | Slight.         | Slight, white. | .03    | 5.60                    | .0000    | .0000       | 0.88      | .0070       | .0000     | .0078            | 1.3       | .0070 |

\* Milky at first; a few hours later, 0.25.

† This determination was made after the water had been filtered through filter-paper.

Odor, none. — The samples were collected from tubular test wells in Hingham, located as follows: No. 14758, in the valley of Weir River, just above Union Street; No. 14848, at the junction of two roads above High Street; No. 14903, beside a pond on South Pleasant Street.

*Microscopical Examination.*

No organisms.

## HINSDALE.

## WATER SUPPLY OF HINSDALE FIRE DISTRICT, HINSDALE.

*Chemical Examination of Water from the Storage Reservoir of the Hinsdale Fire District.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |             |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Sus-pended. |           |             |           |                  |           |
| 1895.   |                     |             |            |        |                         |                   |          |             |            |             |           |             |           |                  |           |
| 13688   | Jan. 17             | Distinct.   | V. slight. | .45    | 3.55                    | 1.35              | .0000    | .0212       | .0154      | .0058       | .09       | .0000       | .0000     | .4740            | 0.9       |
| 13865   | Feb. 20             | None.       | V. slight. | .15    | 2.15                    | 0.70              | .0000    | .0130       | .0090      | .0040       | .10       | .0070       | .0000     | .3053            | 0.5       |
| 13866   | Feb. 20             | None.       | V. slight. | .15    | 2.25                    | 1.00              | .0002    | .0124       | .0110      | .0014       | .08       | .0050       | .0000     | .2855            | 0.5       |
| 14027   | Mar. 20             | V. slight.  | V. slight. | .28    | 3.20                    | 1.20              | .0056    | .0160       | .0134      | .0026       | .07       | .0000       | .0001     | .4700            | 1.1       |
| 14374   | May 27              | Slight.     | Slight.    | .12    | 2.50                    | 0.95              | .0002    | .0106       | .0090      | .0016       | .07       | .0000       | .0000     | .2660            | 0.9       |
| 14547   | June 26             | Distinct.   | Cons.      | .20    | 3.05                    | 1.25              | .0000    | .0184       | .0094      | .0090       | .05       | .0000       | .0000     | .3425            | 0.0       |
| 14724   | July 29             | Decided.    | Cons.      | .18    | 3.00                    | 1.90              | .0000    | .0276       | .0170      | .0106       | .11       | .0030       | .0002     | .5852            | 0.2       |
| 15270   | Sept. 26            | Decided.    | Slight.    | .65    | 4.55                    | 3.05              | .0004    | .0318       | .0206      | .0112       | .08       | .0030       | .0000     | .7410            | 0.6       |
|         |                     | green.      | green.     |        |                         |                   |          |             |            |             |           |             |           |                  |           |
| 15447   | Oct. 29             | Decided.    | Cons.      | .75    | 5.20                    | 3.65              | .0000    | .0542       | .0340      | .0202       | .08       | .0000       | .0000     | .9477            | 0.6       |
|         |                     | green.      | green.     |        |                         |                   |          |             |            |             |           |             |           |                  |           |
| 15623   | Nov. 26             | Decided.    | Cons.      | .40    | 2.70                    | 1.55              | .0000    | .0444       | .0180      | .0284       | .07       | .0000       | .0000     | .6006            | 0.2       |
|         |                     | green.      | green.     |        |                         |                   |          |             |            |             |           |             |           |                  |           |
| 15794   | Dec. 23             | Distinct.   | Slight.    | .35    | 2.80                    | 1.45              | .0008    | .0338       | .0202      | .0136       | .06       | .0000       | .0000     | .5082            | 0.2       |
|         |                     |             |            |        |                         |                   |          |             |            |             |           |             |           |                  |           |
| Av.*    | .....               | .....       | .....      | .35    | 3.27                    | 1.72              | .0002    | .0271       | .0165      | .0106       | .08       | .0012       | .0000     | .5231            | 0.5       |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

Odor, generally vegetable; in May, distinctly oily; on heating, sometimes unpleasant. — Nos. 13865, 13866, 14547 and 15623 were collected from the reservoir and the others from a faucet in the village.

*Microscopical Examination of Water from the Storage Reservoir of the Hinsdale Fire District.*

[Number of organisms per cubic centimeter.]

|                             | 1895. |       |       |       |       |       |         |         |         |         |        |  |
|-----------------------------|-------|-------|-------|-------|-------|-------|---------|---------|---------|---------|--------|--|
|                             | Jan.  | Feb.  | Feb.  | Mar.  | May   | June. | July.   | Sept.   | Oct.    | Nov.    | Dec.   |  |
| Day of examination, . . . . | 19    | 23    | 23    | 21    | 28    | 28    | 31      | 28      | 31      | 27      | 26     |  |
| Number of sample, . . . .   | 13688 | 13865 | 13866 | 14027 | 14374 | 14547 | 14724   | 15270   | 15447   | 15623   | 15794  |  |
| PLANTS.                     |       |       |       |       |       |       |         |         |         |         |        |  |
| Diatomaceæ, . . . .         | 0     | 3     | 1     | 0     | 0     | 29    | 0       | 0       | 0       | 0       | 0      |  |
| Synedra, . . . .            | 0     | 3     | 1     | 0     | 0     | 20    | 0       | 0       | 0       | 0       | 0      |  |
| Tabellaria, . . . .         | 0     | 0     | 0     | 0     | 0     | 9     | 0       | 0       | 0       | 0       | 0      |  |
| Algæ, . . . . .             | 422   | 32    | 0     | 0     | 1     | 57    | 400,002 | 250,000 | 160,000 | 180,000 | 29,200 |  |
| Glaucocapsa, . . . .        | 0     | 0     | 0     | 0     | 1     | 9     | 2       | 0       | 0       | 0       | 0      |  |
| Palmella, . . . .           | 420   | 0     | 0     | 0     | 0     | 48    | 400,000 | 250,000 | 160,000 | 180,000 | 29,200 |  |
| Protozoocna, . . . .        | 2     | 32    | 0     | 0     | 0     | 0     | 0       | 0       | 0       | 0       | 0      |  |
| Fungi, Crenothrix, . . . .  | 0     | 0     | 0     | 0     | 12    | 28    | 0       | 0       | 0       | 0       | 0      |  |

## HINSDALE.

*Microscopical Examination of Water from the Storage Reservoir of the Hinsdale Fire District — Concluded.*

[Number of organisms per cubic centimeter.]

|                                | 1895. |      |      |      |      |      |         |         |         |         |        |  |
|--------------------------------|-------|------|------|------|------|------|---------|---------|---------|---------|--------|--|
|                                | Jan.  | Feb. | Feb. | Mar. | May. | June | July.   | Sept.   | Oct.    | Nov.    | Dec.   |  |
| ANIMALS.                       |       |      |      |      |      |      |         |         |         |         |        |  |
| Infusoria, . . . . .           | 51    | 13   | 4    | 42   | 226  | 276  | 4       | 0       | 0       | 600     | 600    |  |
| Ciliated Infusorian, . . . . . | 0     | 0    | 0    | 0    | 0    | 0    | 0       | 0       | 0       | 550     | 0      |  |
| Cryptomonas, . . . . .         | 40    | 0    | 0    | 1    | 0    | 0    | 0       | 0       | 0       | 0       | 0      |  |
| Dinobryon, . . . . .           | 0     | 0    | 0    | 1    | 4    | 0    | 0       | 0       | 0       | 0       | 0      |  |
| Dinobryon cases, . . . . .     | 0     | 0    | 3    | 0    | 216  | 0    | 0       | 0       | 0       | 0       | 0      |  |
| Euglena, . . . . .             | 1     | 4    | 0    | 1    | 0    | 0    | 0       | 0       | 0       | 0       | 0      |  |
| Monas, . . . . .               | 0     | 0    | 0    | 0    | 0    | 0    | 0       | 0       | 0       | 50      | 0      |  |
| Peridinium, . . . . .          | 8     | 9    | 1    | 38   | 6    | 276  | 2       | 0       | 0       | 0       | 600    |  |
| Trachelomonas, . . . . .       | 2     | 0    | 0    | 1    | 0    | 0    | 2       | 0       | 0       | 0       | 0      |  |
| Ferres, Polyarthra, . . . . .  | 0     | 6    | 0    | 0    | 0    | 0    | 2       | 0       | 0       | 0       | 0      |  |
| TOTAL, . . . . .               | 473   | 54   | 5    | 42   | 239  | 390  | 400,008 | 250,000 | 160,000 | 180,600 | 29,800 |  |

## WATER SUPPLY OF HOLBROOK.

(See Randolph)

## HOLDEN.

The advice of the State Board of Health to the town of Holden with reference to the introduction of a water supply into that town from sources in the towns of Rutland and Holden may be found on pages 28 and 29 of this volume. The results of an analysis of a sample of water from Pine Hill reservoir in Holden are given below. Analyses of water from Muschopauge Pond in Rutland may be found under Rutland.

*Chemical Examination of Water from Pine Hill Reservoir, Holden.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |       | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           |             |       |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |       |                  |           |
| 13769   | 1895.<br>Feb. 5     | V. slight.  | V. slight. | .25    | 4.00                    | .95               | .0042    | .0126       | .0110      | .0016      | .17       | .0280       | .0000 | .3831            | 1.4       |

Odor, none, becoming distinctly vegetable on heating.

*Microscopical Examination.*

Diatomaceæ, *Eptihemia*, 1. Infusoria, *Dinobryon*, 4; *Dinobryon cases*, 3. Miscellaneous, *Zoöglaea*, 1. Total, 9.

## HOLYOKE.

## WATER SUPPLY OF HOLYOKE.

device of the State Board of Health to the city of Holyoke to a proposed additional water supply for the city may be on pages 29 and 30 of this volume. Analyses of samples of collected in connection with the investigation of the proposed of additional supply may be found on page 180.

*Examination of Water from Whiting Street Storage Reservoir, Holyoke.*

[Parts per 100,000.]

| APPEARANCE.  |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |        |                           |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|--------------|-------------------|--------|---------------------------------|----------------------|----------|--------|---------------------------|-----------------|-----------|----------------|-----------|------------------|-----------|
| Turbidity.   | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Total. | Albuminoid.<br>Dissolved. | Sus-<br>pended. |           | Nitrates.      | Nitrites. |                  |           |
| 3 Slight.    | Slight.           | .20    | 5.85                            | 1.60                 | .0082    | .0160  | .0148                     | .0012           | .18       | .0070          | .0000     | .2646            | 3.4       |
| 6 None.      | Slight.           | .25    | 6.25                            | 1.20                 | .0166    | .0138  | .0124                     | .0014           | .19       | .0080          | .0003     | .2860            | 3.6       |
| 2 Slight.    | Slight.           | .18    | 4.35                            | 1.65                 | .0000    | .0174  | .0120                     | .0054           | .14       | .0000          | .0000     | .2660            | 2.5       |
| 4 Decided.   | Cons.,<br>yellow. | .25    | 5.25                            | 1.80                 | .0042    | .0462  | .0258                     | .0204           | .14       | .0000          | .0001     | .3835            | 2.7       |
| 4 Distinct.  | Cons.,<br>brown.  | .20    | 6.25                            | 2.15                 | .0002    | .0530  | .0292                     | .0244           | .12       | .0080          | .0000     | .3666            | 3.4       |
| 0 Distinct.  | Cons.,<br>green.  | .20    | 5.70                            | 1.80                 | .0006    | .0402  | .0292                     | .0110           | .17       | .0000          | .0000     | .4212            | 3.1       |
| 0 V. slight. | Cons.             | .30    | 5.70                            | 1.70                 | .0094    | .0308  | .0212                     | .0096           | .15       | .0070          | .0000     | .2911            | 3.1       |
| .....        | .....             | .23    | 5.62                            | 1.70                 | .0056    | .0311  | .0206                     | .0105           | .16       | .0043          | .0001     | .3256            | 3.1       |

*Averages by Years.**From Brook before Reservoir was built.*

|   |   |     |      |      |       |       |       |       |     |       |       |   |   |
|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|---|---|
| - | - | .48 | 7.80 | 1.44 | .0024 | .0204 | -     | -     | .13 | .0126 | -     | - | - |
| - | - | .25 | 6.63 | 1.22 | .0009 | .0183 | -     | -     | .10 | .0081 | .0001 | - | - |
| - | - | .14 | 6.72 | 1.02 | .0006 | .0134 | .0092 | .0042 | .11 | .0054 | .0001 | - | - |

*From Reservoir.*

|   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | - | .30 | 6.95 | 1.60 | .0008 | .0244 | .0183 | .0056 | .15 | .0120 | .0000 | -     | 3.6 |
| - | - | .41 | 6.34 | 2.05 | .0125 | .0311 | .0253 | .0058 | .12 | .0185 | .0006 | -     | 3.1 |
| - | - | .30 | 5.57 | 1.86 | .0029 | .0294 | .0247 | .0047 | .14 | .0192 | .0001 | -     | 2.8 |
| - | - | .18 | 4.67 | 1.63 | .0008 | .0251 | .0183 | .0088 | .13 | .0063 | .0001 | .3538 | 2.5 |
| - | - | .27 | 5.03 | 1.29 | .0007 | .0204 | .0155 | .0049 | .16 | .0067 | .0000 | .3343 | 2.9 |
| - | - | .23 | 5.62 | 1.70 | .0056 | .0311 | .0206 | .0105 | .16 | .0043 | .0001 | .3256 | 3.1 |

\* June to December.

† January to May.

‡ December.

analyses of 1895: Odor of the first and last samples, none; of the others, vegetable. — were collected from the reservoir.

**HOLYOKE.***Microscopical Examination of Water from Whiting Street Storage Reservoir  
Holyoke.*

[Number of organisms per cubic centimeter.]

|                               | 1898. |       |       |        |       |       |       |
|-------------------------------|-------|-------|-------|--------|-------|-------|-------|
|                               | Jan.  | Feb.  | May.  | June.  | Sept. | Nov.  | Dec.  |
| Day of examination, . . . . . | 24    | 28    | 24    | 26     | 26    | 1     | 24    |
| Number of sample, . . . . .   | 18709 | 13893 | 14356 | 14535  | 15251 | 15452 | 15783 |
| <b>PLANTS.</b>                |       |       |       |        |       |       |       |
| Diatomaceæ, . . . . .         | 100   | 23    | 45    | 17,800 | 0     | 136   | 294   |
| Asterionella, . . . . .       | 100   | 14    | 8     | 400    | 0     | 132   | 0     |
| Diatoma, . . . . .            | 0     | 8     | 0     | 0      | 0     | 0     | 0     |
| Fragilaria, . . . . .         | 0     | 0     | 37    | 17,600 | 0     | 2     | 4     |
| Synedra, . . . . .            | 0     | 1     | 0     | 0      | 0     | 2     | 260   |
| Cyanophyceæ, . . . . .        | 0     | 0     | 0     | 2,450  | 2     | 25    | 1     |
| Anabaena, . . . . .           | 0     | 0     | 0     | 2,450  | 0     | 0     | 0     |
| Aphanocapsa, . . . . .        | 0     | 0     | 0     | 0      | 0     | 20    | 1     |
| Microcystis, . . . . .        | 0     | 0     | 0     | 0      | 2     | 5     | 0     |
| Algae, . . . . .              | 0     | 0     | 18    | 0      | 2,465 | 79    | 198   |
| Chlorococcus, . . . . .       | 0     | 0     | 12    | 0      | 0     | 0     | 0     |
| Cosmarium, . . . . .          | 0     | 0     | 0     | 0      | 276   | 1     | 0     |
| Protooccus, . . . . .         | 0     | 0     | 0     | 0      | 2,000 | 15    | 0     |
| Raphidium, . . . . .          | 0     | 0     | 0     | 0      | 20    | 9     | 36    |
| Scenedesmus, . . . . .        | 0     | 0     | 1     | 0      | 124   | 32    | 160   |
| Staurostrum, . . . . .        | 0     | 0     | 3     | 0      | 32    | 20    | 2     |
| Staurogenia, . . . . .        | 0     | 0     | 0     | 0      | 8     | 2     | 0     |
| Zoöspores, . . . . .          | 0     | 0     | 0     | 0      | 5     | 0     | 0     |
| Fungi, Crenothrix, . . . . .  | 1     | 5     | 0     | 0      | 0     | 0     | 0     |
| <b>ANIMALS.</b>               |       |       |       |        |       |       |       |
| Infusoria, . . . . .          | 1     | 0     | 717   | 0      | 547   | 121   | 173   |
| Codonella, . . . . .          | 0     | 0     | 0     | 0      | 3     | 0     | 0     |
| Dinobryon, . . . . .          | 0     | 0     | 68    | 0      | 0     | 0     | 0     |
| Dinobryon cases, . . . . .    | 0     | 0     | 648   | 0      | 0     | 0     | 0     |
| Euglena, . . . . .            | 0     | 0     | 0     | 0      | 1     | 0     | 5     |
| Peridinium, . . . . .         | 1     | 0     | 1     | 0      | 2     | 1     | 0     |
| Tintinnidium, . . . . .       | 0     | 0     | 0     | 0      | 1     | 0     | 0     |
| Trachelomonas, . . . . .      | 0     | 0     | 0     | 0      | 540   | 120   | 168   |
| Vermes, . . . . .             | 1     | 2     | 1     | 0      | 4     | 1     | 0     |
| Anurea, . . . . .             | 1     | 2     | 1     | 0      | 0     | 0     | 0     |
| Polyarthra, . . . . .         | 0     | 0     | 0     | 0      | 0     | 1     | 0     |
| Rotatorian ova, . . . . .     | 0     | 0     | 0     | 0      | 1     | 0     | 0     |
| Rotifer, . . . . .            | 0     | 0     | 0     | 0      | 3     | 0     | 0     |
| Crustacea, Bosmina, . . . . . | 0     | 0     | 0     | 0      | .04   | 0     | 0     |
| <b>Miscellaneous.</b>         |       |       |       |        |       |       |       |
| Acarina, . . . . .            | 0     | 0     | 0     | 0      | .20   | 0     | 0     |
| Zoöglæa, . . . . .            | 0     | 2     | 108   | 0      | 12    | 20    | 80    |
| TOTAL, . . . . .              | 103   | 32    | 887   | 20,350 | 3,030 | 382   | 716   |

## HOLYOKE.

*Chemical Examination of Water from Wright and Ashley Ponds, Holyoke.*

[Parts per 100,000]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |             |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Sus-pended. |           |             |           |                  |           |
| 1895.   |                     |             |            |        |                         |                   |          |             |            |             |           |             |           |                  |           |
| 13708   | Jan. 23             | Slight.     | Slight.    | .30    | 5.35                    | 1.80              | .0112    | .0298       | .0248      | .0050       | .26       | .0070       | .0001     | .4226            | 2.9       |
| 13892   | Feb. 26             | V. slight.  | V. slight. | .37    | 6.10                    | 2.20              | .0080    | .0504       | .0454      | .0050       | .25       | .0180       | .0001     | .5253            | 3.2       |
| 14354   | May 22              | Slight.     | Slight.    | .05    | 5.35                    | 1.40              | .0006    | .0116       | .0106      | .0010       | .19       | .0000       | .0000     | .1900            | 3.2       |
| 14534   | June 24             | Slight.     | Slight.    | .18    | 5.45                    | 1.65              | .0014    | .0170       | .0158      | .0012       | .17       | .0000       | .0000     | .2772            | 2.7       |
| 15250   | Sept. 24            | V. slight.  | V. slight. | .15    | 5.20                    | 1.55              | .0022    | .0220       | .0194      | .0026       | .16       | .0050       | .0000     | .3237            | 2.9       |
| 15451   | Oct. 30             | Slight.     | Slight.    | .18    | 5.25                    | 1.35              | .0026    | .0180       | .0138      | .0042       | .16       | .0030       | .0001     | .2730            | 3.1       |
| 15782   | Dec. 20             | V. slight.  | V. slight. | .20    | 5.15                    | 1.80              | .0036    | .0300       | .0280      | .0020       | .16       | .0070       | .0001     | .3426            | 2.9       |
| Av.     | .....               | .....       | .....      | .20    | 5.41                    | 1.68              | .0042    | .0255       | .0225      | .0030       | .19       | .0057       | .0001     | .3363            | 3.0       |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | .08 | 5.25 | 0.89 | .0029 | .0202 | -     | -     | .13 | .0016 | -     | -     | -   |
| - | 1888  | - | - | .06 | 4.81 | 0.82 | .0024 | .0178 | -     | -     | .12 | .0054 | .0001 | -     | -   |
| - | 1889  | - | - | .02 | 5.37 | 0.74 | .0020 | .0201 | .0161 | .0040 | .13 | .0039 | .0000 | -     | -   |
| - | 1890  | - | - | .01 | -    | -    | .0020 | .0201 | .0151 | .0050 | .13 | .0048 | .0000 | -     | -   |
| - | 1891† | - | - | .01 | 6.10 | -    | .0046 | .0243 | .0201 | .0042 | .13 | .0035 | .0001 | -     | 2.9 |
| - | 1892‡ | - | - | .02 | 5.10 | 1.15 | .0008 | .0196 | .0154 | .0042 | .17 | .0020 | .0000 | -     | 3.1 |
| - | 1893  | - | - | .06 | 4.71 | 1.21 | .0026 | .0195 | .0152 | .0043 | .15 | .0072 | .0000 | .2466 | 3.1 |
| - | 1894  | - | - | .09 | 5.14 | 1.83 | .0022 | .0215 | .0179 | .0036 | .17 | .0045 | .0000 | .2611 | 2.9 |
| - | 1895  | - | - | .20 | 5.41 | 1.68 | .0042 | .0255 | .0225 | .0030 | .19 | .0057 | .0001 | .3363 | 3.0 |

\* June to December.

† July and October.

‡ May.

NOTE to analyses of 1895: Odor, vegetable. — The samples were collected from Ashley Pond.

*Microscopical Examination of Water from Wright and Ashley Ponds, Holyoke.*

[Number of organisms per cubic centimeter.]

|                               | 1895. |       |       |       |       |       |       |
|-------------------------------|-------|-------|-------|-------|-------|-------|-------|
|                               | Jan.  | Feb.  | May.  | June. | Sept. | Nov.  | Dec.  |
| Day of examination, . . . . . | 24    | 28    | 24    | 26    | 26    | 1     | 24    |
| Number of sample, . . . . .   | 13708 | 13892 | 14354 | 14534 | 15250 | 15451 | 15782 |
| <b>PLANTS.</b>                |       |       |       |       |       |       |       |
| Diatomaceæ, . . . . .         | 3     | 0     | 86    | 356   | 16    | 0     | 0     |
| Asterionella, . . . . .       | 0     | 0     | 0     | 252   | 16    | 0     | 0     |
| Cyclotella, . . . . .         | 0     | 0     | 18    | 80    | 0     | 0     | 0     |
| Fragilaria, . . . . .         | 0     | 0     | 0     | 70    | 0     | 0     | 0     |
| Melosira, . . . . .           | 0     | 0     | 28    | 0     | 0     | 0     | 0     |
| Synedra, . . . . .            | 3     | 0     | 40    | 4     | 0     | 0     | 0     |



**HOLYOKE.***Microscopical Examination of Water from Wright and Ashley Ponds, Holyoke—*  
Concluded.

[Number of organisms per cubic centimeter.]

|                                          | 1895. |      |      |       |       |      |      |
|------------------------------------------|-------|------|------|-------|-------|------|------|
|                                          | Jan.  | Feb. | May. | June. | Sept. | Nov. | Dec. |
| <b>PLANTS—Con.</b>                       |       |      |      |       |       |      |      |
| <b>Cyanophyceæ, . . . . .</b>            | 0     | 0    | 0    | 13    | 260   | 0    | 0    |
| <i>Anabæna, . . . . .</i>                | 0     | 0    | 0    | 1     | 120   | 0    | 0    |
| <i>Chroococcus, . . . . .</i>            | 0     | 0    | 0    | 0     | 140   | 0    | 0    |
| <i>Microcystis, . . . . .</i>            | 0     | 0    | 0    | 12    | 0     | 0    | 0    |
| <b>Algæ, . . . . .</b>                   | 0     | 0    | 13   | 51    | 30    | 0    | 0    |
| <i>Protococcus, . . . . .</i>            | 0     | 0    | 13   | 25    | 30    | 0    | 0    |
| <i>Staurogenia, . . . . .</i>            | 0     | 0    | 0    | 25    | 0     | 0    | 0    |
| <b>ANIMALS.</b>                          |       |      |      |       |       |      |      |
| <b>Infusoria, . . . . .</b>              | 35    | 13   | 2    | 1     | 0     | 0    | 64   |
| Ciliated infusorian, . . . . .           | 0     | 0    | 1    | 0     | 0     | 0    | 0    |
| Dinobryon cases, . . . . .               | 0     | 0    | 0    | 1     | 0     | 0    | 0    |
| Mallomonas, . . . . .                    | 5     | 0    | 0    | 0     | 0     | 0    | 0    |
| Monas, . . . . .                         | 0     | 0    | 1    | 0     | 0     | 0    | 0    |
| Peridinium, . . . . .                    | 29    | 12   | 0    | 0     | 0     | 0    | 64   |
| Trachelomonas, . . . . .                 | 1     | 1    | 0    | 0     | 0     | 0    | 0    |
| <b>Miscellaneous, Zoöglæa, . . . . .</b> | 2     | 15   | 60   | 0     | 0     | 0    | 0    |
| <b>TOTAL, . . . . .</b>                  | 40    | 28   | 161  | 421   | 306   | 0    | 64   |

*Chemical Examination of Water from Tucker and Manhan Brooks, Southampton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.   |                     |             |            |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 14795   | Aug. 9              | V. slight.  | V. slight. | .35    | 4.15                    | 1.25              | .0004    | .0110       | .0092      | .0018      | .16       | .0020       | .0000     | .4758            | 1.1       |
| 14935   | Aug. 28             | None.       | V. slight. | .12    | 3.80                    | 0.80              | .0014    | .0036       | .0030      | .0006      | .12       | .0000       | .0003     | .1482            | 1.3       |
| 14796   | Aug. 9              | V. slight.  | V. slight. | .15    | 4.70                    | 1.15              | .0014    | .0048       | .0040      | .0008      | .10       | .0030       | .0000     | .3042            | 2.7       |
| 14934   | Aug. 28             | None.       | V. slight. | .12    | 4.75                    | 1.15              | .0012    | .0082       | .0072      | .0010      | .16       | .0000       | .0002     | .1560            | 2.2       |

Odor of the first sample, none; of the second, faintly vegetable, becoming stronger on heating; of the third, faintly mouldy; of the last, faintly vegetable, becoming stronger and also musty on heating. — The first sample was collected from Tucker Brook,  $\frac{1}{2}$  mile above its junction with Manhan Brook; the second, from Tucker Brook, just above the junction; the third, from Manhan Brook,  $\frac{1}{2}$  mile above its junction with Tucker Brook; and the last, from Manhan Brook, just above the junction of the two brooks.

*Microscopical Examination.*

An insignificant number of organisms was found in each of these samples.

HUDSON.

WATER SUPPLY OF HUDSON.

*Chemical Examination of Water from Gates Pond, Berlin.*

[Parts per 100,000.]

| NUMBER. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Lost on<br>ignition. | Free.    | Albuminoid. |            |                |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended |           |                |           |                  |           |
| 21      | 1895.<br>Jan. 8     | V. slight.  | V. slight. | .04    | 2.45                            | 0.95                 | .0006    | .0240       | .0152      | .0088          | .25       | .0000          | .0000     | .2005            | 0.9       |
| 60      | Feb. 12             | Slight.     | Slight.    | .05    | 2.85                            | 0.85                 | .0002    | .0260       | .0172      | .0088          | .27       | .0030          | .0000     | .3400            | 1.3       |
| 62      | Mar. 12             | V. slight.  | V. slight. | .02    | 2.20                            | 0.55                 | .0016    | .0132       | .0116      | .0016          | .25       | .0050          | .0000     | .1809            | 0.8       |
| 50      | Apr. 16             | Distinct.   | Slight.    | .07    | 2.20                            | 0.90                 | .0038    | .0150       | .0118      | .0032          | .20       | .0020          | .0000     | .1935            | 1.0       |
| 80      | May 13              | Slight.     | Cons.      | .04    | 2.55                            | 0.75                 | .0020    | .0150       | .0126      | .0024          | .19       | .0050          | .0000     | .1675            | 1.4       |
| 66      | June 12             | Slight.     | Slight.    | .03    | 2.60                            | 1.20                 | .0028    | .0170       | .0152      | .0018          | .17       | .0000          | .0000     | .1755            | 0.8       |
| 41      | July 17             | V. slight.  | Slight.    | .05    | 1.85                            | 0.80                 | .0000    | .0174       | .0158      | .0016          | .22       | .0000          | .0000     | .1237            | 0.6       |
| 43      | Aug. 15             | Distinct.   | Slight.    | .03    | 2.70                            | 0.85                 | .0000    | .0162       | .0140      | .0022          | .24       | .0000          | .0000     | .1872            | 0.5       |
| 26      | Sept. 10            | Slight.     | Slight.    | .03    | 2.25                            | 1.20                 | .0004    | .0164       | .0152      | .0012          | .25       | .0000          | .0001     | .2418            | 0.9       |
| 49      | Oct. 10             | V. slight.  | Slight.    | .12    | 2.30                            | 0.85                 | .0012    | .0196       | .0164      | .0032          | .22       | .0050          | .0000     | .2246            | 0.8       |
| 54      | Nov. 15             | Slight.     | Slight.    | .07    | 2.55                            | 1.10                 | .0008    | .0150       | .0134      | .0016          | .25       | .0050          | .0000     | .2067            | 0.9       |
| 48      | Dec. 17             | V. slight.  | V. slight. | .07    | 2.95                            | 1.10                 | .0048    | .0156       | .0146      | .0010          | .29       | .0070          | .0000     | .1963            | 1.1       |
| 7.      | .....               | .....       | .....      | .05    | 2.45                            | 0.92                 | .0015    | .0175       | .0144      | .0031          | .23       | .0027          | .0000     | .2032            | 0.9       |

*Averages by Years.*

|       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |   |
|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|---|
| 1887* | - | - | .06 | 3.17 | 0.71 | .0014 | .0150 | -     | -     | .21 | .0054 | -     | -     | -   | - |
| 1888  | - | - | .06 | 2.55 | 0.69 | .0015 | .0158 | -     | -     | .19 | .0055 | .0001 | -     | -   | - |
| 1889  | - | - | .03 | 2.14 | 0.58 | .0020 | .0189 | .0139 | .0050 | .19 | .0048 | .0001 | -     | -   | - |
| 1890  | - | - | .02 | 2.82 | 1.04 | .0023 | .0161 | .0124 | .0037 | .21 | .0054 | .0000 | -     | 1.2 | - |
| 1891  | - | - | .04 | 2.52 | 0.90 | .0011 | .0150 | .0117 | .0033 | .20 | .0074 | .0000 | -     | 0.9 | - |
| 1893  | - | - | .05 | 2.45 | 1.01 | .0040 | .0178 | .0146 | .0032 | .23 | .0039 | .0000 | .1965 | 0.6 | - |
| 1894  | - | - | .04 | 2.27 | 0.83 | .0016 | .0148 | .0124 | .0024 | .22 | .0008 | .0000 | .1452 | 0.6 | - |
| 1895  | - | - | .05 | 2.45 | 0.92 | .0015 | .0175 | .0144 | .0031 | .23 | .0027 | .0000 | .2032 | 0.9 | - |

\* June to December.

**NOTE** to analyses of 1895: Odor of the first four samples, decidedly disagreeable; of the others, slightly vegetable or none.—The samples were collected from the pond. For monthly height of water in this pond, see page 182.

## HUDSON.

*Microscopical Examination of Water from Gates Pond, Berlin.*

[Number of organisms per cubic centimeter.]

|                               | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|-------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                               | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .     | 8     | 14    | 14    | 17    | 14    | 13    | 19    | 16    | 11    | 11    | 16    | 18    |
| Number of sample, . . .       | 13621 | 13800 | 13902 | 14150 | 14280 | 14466 | 14641 | 14843 | 15126 | 15349 | 15554 | 15748 |
| <b>PLANTS.</b>                |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .             | 0     | 1     | 0     | 109   | 47    | 6     | 3     | 21    | 2     | 48    | 315   | 40    |
| Asterionella, . . .           | 0     | pr.   | 0     | 3     | 20    | 0     | 0     | 0     | 0     | 6     | 38    | 30    |
| Cyclotella, . . .             | 0     | 1     | 0     | 0     | 0     | 1     | 1     | 4     | 1     | 0     | 0     | 0     |
| Fragilaria, . . .             | 0     | 0     | 0     | 0     | 0     | 1     | 2     | 2     | 0     | 0     | 0     | 0     |
| Melosira, . . .               | 0     | 0     | 0     | 51    | 0     | 0     | 0     | 4     | 0     | 34    | 236   | 0     |
| Navicula, . . .               | 0     | 0     | 0     | 1     | 0     | pr.   | 0     | 1     | 0     | 4     | 2     | 0     |
| Synedra, . . .                | 0     | 0     | 0     | 48    | 13    | 0     | 0     | 6     | 0     | 3     | 36    | 6     |
| Tabellaria, . . .             | 0     | 0     | 0     | 6     | 14    | 4     | 0     | 4     | 1     | 1     | 3     | 4     |
| Cyanophyceæ, . . .            | 0     | 0     | 0     | 0     | 0     | 189   | 85    | 196   | 52    | 72    | 4     | 0     |
| Anabaena, . . .               | 0     | 0     | 0     | 0     | 0     | 118   | 0     | 0     | 0     | 0     | 0     | 0     |
| Merismopedia, . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 50    | 0     | 0     | 0     | 0     | 0     |
| Microcystis, . . .            | 0     | 0     | 0     | 0     | 0     | 71    | 35    | 196   | 52    | 72    | 4     | 0     |
| Algae, . . .                  | 0     | pr.   | 0     | 2     | 15    | 9     | 463   | 109   | 8     | 28    | 29    | 0     |
| Arthrodesmus, . . .           | 0     | 0     | 0     | 1     | 5     | 1     | 2     | 0     | 0     | 0     | 1     | 0     |
| Pediastrum, . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 9     | 0     | 0     | 0     | 0     |
| Protocecus, . . .             | 0     | pr.   | 0     | 1     | 4     | 7     | 440   | 76    | 0     | 8     | 8     | 0     |
| Raphidium, . . .              | 0     | 0     | 0     | 0     | 0     | 1     | 21    | 18    | 7     | 19    | 20    | 0     |
| Staurastrum, . . .            | 0     | 0     | 0     | 0     | 6     | 0     | 0     | 0     | 1     | 1     | 0     | 0     |
| Staurogenia, . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 6     | 0     | 0     | 0     | 0     |
| <b>ANIMALS.</b>               |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . .              | 108   | 9,355 | 0     | 37    | 110   | 0     | 37    | 3     | 15    | 19    | 20    | 3     |
| Ceratum, . . .                | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     |
| Codonella, . . .              | 8     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     |
| Cryptomonas, . . .            | 54    | 4,800 | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon, . . .              | 40    | 300   | 0     | 23    | 0     | 0     | 34    | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, . . .        | 0     | 4,200 | 0     | 12    | 104   | 0     | 0     | 0     | 2     | 1     | 17    | 1     |
| Euglena, . . .                | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Mallomonas, . . .             | 0     | 50    | 0     | 0     | 0     | 0     | 3     | 0     | 0     | 1     | 0     | 0     |
| Peridinium, . . .             | 2     | 3     | 0     | 2     | 6     | 0     | 0     | 3     | 11    | 2     | 2     | 2     |
| Trachelomonas, . . .          | 2     | pr.   | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 13    | 0     | 0     |
| Miscellaneous, Zoöglæa, . . . | 0     | 0     | 0     | 0     | 52    | 0     | 0     | 24    | 0     | 100   | 7     | 0     |
| TOTAL, . . .                  | 106   | 9,356 | 0     | 148   | 224   | 204   | 588   | 353   | 77    | 267   | 375   | 43    |

Table showing Heights of Water in Gates Pond Each Month during 1895.

[High-water mark is 14 feet.]

| DATE. — 1895.   | Feet. | DATE. — 1895.   | Feet. |
|-----------------|-------|-----------------|-------|
| Jan. 15, . . .  | 9.8   | July 15, . . .  | 9.5   |
| Feb. 15, . . .  | 9.2   | Aug. 15, . . .  | 9.1   |
| March 15, . . . | 9.2   | Sept. 15, . . . | 8.5   |
| April 15, . . . | 10.3  | Oct. 15, . . .  | 8.7   |
| May 15, . . .   | 10.6  | Nov. 15, . . .  | 9.3   |
| June 15, . . .  | 10.0  | Dec. 15, . . .  | 10.0  |

HULL.

## WATER SUPPLY OF HULL.

(See *Hingham*.)

## 3 SUPPLY OF HYDE PARK AND MILTON. — HYDE PARK WATER COMPANY.

## 1 Examination of Water from the Wells of the Hyde Park Water Company.

[Parts per 100,000.]

|     | APPEARANCE. |                |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|-----|-------------|----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|     | Turbidity.  | Sediment.      | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 14  | None.       | None.          | .02    | 5.10                    | .0046    | .0042       | 1.53      | .0750       | .0000     | .0774            | 4.2       | .0030 |
| 18  | V. slight.  | V. slight.     | .01    | 9.30                    | .0046    | .0028       | 1.30      | .0780       | .0001     | .0741            | 3.8       | .0120 |
| 18  | None.       | None.          | .00    | 9.15                    | .0038    | .0016       | 1.18      | .0900       | .0001     | .0790            | 4.4       | .0075 |
| 15  | None.       | None.          | .02    | 9.10                    | .0038    | .0020       | 1.21      | .1200       | .0003     | .0727            | 4.1       | .0140 |
| 15  | None.       | None.          | .04    | 8.40                    | .0034    | .0028       | 1.06      | .1100       | .0001     | .0513            | 3.6       | .0020 |
| 18  | None.       | V. slight.     | .04    | 9.60                    | .0032    | .0026       | 1.04      | .0900       | .0000     | .0484            | 3.6       | .0000 |
| 22  | V. slight.  | Slight.        | .08    | 10.50                   | .0050    | .0060       | 1.27      | .1050       | .0003     | .1200            | 4.4       | .0100 |
| 20  | None.       | Slight.        | .05    | 11.90                   | .0074    | .0040       | 1.33      | .0900       | .0001     | .1014            | 3.9       | .0070 |
| 17  | Slight.     | Slight, rusty. | .08    | 10.90                   | .0098    | .0048       | 1.57      | .0650       | .0001     | .1248            | 4.2       | .0165 |
| 15  | V. slight.  | V. slight.     | .03    | 11.00                   | .0132    | .0040       | 1.74      | .0780       | .0002     | .1373            | 4.7       | .0190 |
| 19  | V. slight.  | V. slight.     | .03    | 9.60                    | .0108    | .0038       | 1.38      | .0820       | .0002     | .0975            | 4.0       | .0120 |
| 17  | None.       | Slight.        | .04    | 8.80                    | .0060    | .0040       | 1.10      | .0580       | .0002     | .0808            | 3.6       | .0180 |
| ... | .....       | .....          | .04    | 9.44                    | .0063    | .0035       | 1.31      | .0867       | .0001     | .0887            | 4.0       | .0149 |

## Averages by Years.

|      |   |   |     |      |       |       |      |       |       |       |     |       |
|------|---|---|-----|------|-------|-------|------|-------|-------|-------|-----|-------|
| 1896 | - | - | .00 | 6.67 | .0004 | .0012 | 0.82 | .0699 | -     | -     | -   | -     |
| 97   | - | - | .00 | 6.06 | .0001 | .0023 | 0.75 | .0641 | .0002 | -     | -   | -     |
| 98   | - | - | .00 | 5.76 | .0001 | .0019 | 0.68 | .0596 | .0001 | -     | -   | -     |
| 99   | - | - | .02 | 9.35 | .0006 | .0023 | 0.88 | .0550 | .0002 | -     | 4.2 | -     |
| 1900 | - | - | .03 | 9.10 | .0000 | .0040 | 0.96 | .0675 | .0002 | -     | 3.6 | -     |
| 01   | - | - | .00 | 7.20 | .0004 | .0035 | 0.99 | .0500 | .0004 | -     | 3.0 | -     |
| 02   | - | - | .02 | 8.62 | .0031 | .0032 | 1.19 | .0879 | .0002 | .0976 | 3.7 | .0112 |
| 03   | - | - | .03 | 9.68 | .0040 | .0039 | 1.37 | .0843 | .0001 | .0880 | 3.9 | .0175 |
| 04   | - | - | .04 | 9.44 | .0063 | .0035 | 1.31 | .0867 | .0001 | .0887 | 4.0 | .0149 |

June to December.

† January to May.

‡ February and August.

June and September.

|| Two samples in July.

analyses of 1895: Odor, generally none; in August, unpleasant; in October, faintly vegetable samples were collected from a faucet at the pumping station.

**HYDE PARK AND MILTON.***Microscopical Examination of Water from the Wells of the Hyde Park Water Company.*

[Number of organisms per cubic centimeter.]

|                               | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|-------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                               | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .     | 15    | 20    | 19    | 17    | 16    | 20    | 23    | 23    | 18    | 17    | 21    | 20    |
| Number of sample, . . .       | 13659 | 13835 | 13993 | 14149 | 14307 | 14488 | 14659 | 14894 | 15189 | 15371 | 15581 | 15760 |
| <b>PLANTS.</b>                |       |       |       |       |       |       |       |       |       |       |       |       |
| Fungi, . . . . .              | 17    | 56    | 6     | 7     | 0     | 1     | 9     | 8     | 92    | 24    | 3     | 2     |
| Crenothrix, . . . . .         | 17    | 56    | 6     | 7     | 0     | 1     | 9     | 8     | 28    | 24    | 3     | 2     |
| Molds, . . . . .              | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 64    | 0     | 0     | 0     |
| Miscellaneous, Zoöglæa, . . . | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 16    | 76    | 0     | 0     | 0     |
| TOTAL, . . . . .              | 17    | 56    | 6     | 7     | 0     | 1     | 9     | 24    | 168   | 24    | 3     | 2     |

*Chemical Examination of Water from a Faucet in Milton supplied from the Works of the Hyde Park Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1895.</b>        |             |           |        |                         |          |                  |           |             |           |                  |           |       |
| 13776   | Feb. 7              | None.       | None.     | .02    | 7.90                    | .0000    | .0008            | 1.37      | .1100       | .0000     | .0592            | 3.4       | .0000 |
| 13947   | Mar. 7              | None.       | None.     | .00    | 9.60                    | .0006    | .0016            | 1.46      | .1500       | .0000     | .0423            | 3.9       | .0000 |
| 14094   | April 3             | None.       | None.     | .00    | 9.30                    | .0006    | .0024            | 1.25      | .1200       | .0000     | .0423            | 3.8       | .0030 |
| 14428   | June 5              | None.       | None.     | .00    | 10.90                   | .0002    | .0034            | 1.32      | .1300       | .0000     | .0266            | 3.8       | .0020 |
| 14614   | July 12             | None.       | None.     | .05    | 10.80                   | .0002    | .0030            | 1.43      | .1600       | .0001     | .0869            | 4.6       | .0000 |
| 15014   | Sept. 6             | None.       | None.     | .03    | 10.10                   | .0004    | .0022            | 1.68      | .1100       | .0000     | .1170            | 4.0       | .0080 |
| 15317   | Oct. 7              | None.       | None.     | .01    | 10.10                   | .0000    | .0020            | 1.79      | .0800       | .0000     | .0764            | 4.0       | .0080 |
| 15487   | Nov. 6              | None.       | None.     | .03    | 10.00                   | .0000    | .0030            | 1.62      | .0800       | .0000     | .0546            | 4.0       | .0010 |
| 15675   | Dec. 4              | None.       | None.     | .03    | 7.90                    | .0000    | .0016            | 1.56      | .0750       | .0000     | .0741            | 3.4       | .0050 |
| Av.     | .....               | .....       | .....     | .02    | 9.62                    | .0002    | .0022            | 1.50      | .1128       | .0000     | .0644            | 3.9       | .0028 |

Odor, generally none. — The samples were collected from a faucet in the office of the Milton Water Company.

*Microscopical Examination.*

No organisms were found in the samples collected in April, June, September and October. In the other samples small numbers of Crenothrix were found, as follows: in February, 2; in March, 1; in July, 40; in November, 2; in December, 1.

## HYDE PARK AND MILTON.

## Chemical Examination of Water from the Neponset River at Hyde Park.

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |               |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|------------------|---------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.       | Sediment.     | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                  |               |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13659   | 1895.<br>Jan. 14    | Distinct, milky. | Slight.       | 0.95   | 5.20                    | 1.95              | .0006    | .0236       | .0198      | .0038      | 0.71      | .0120       | .0000     | 0.7884           | 1.6       |
| 13434   | Feb. 18             | Decided.         | Cons., gray.  | 0.90   | 11.35                   | 3.00              | .0066    | .0350       | .0268      | .0082      | 1.86      | .0120       | .0002     | 1.1583           | 3.4       |
| 13992   | Mar. 18             | Distinct.        | Slight.       | 0.90   | 5.20                    | 1.95              | .0006    | .0204       | .0196      | .0008      | 0.57      | .0030       | .0000     | 0.8279           | 2.2       |
| 14148   | Apr. 15             | Slight.          | Slight.       | 1.20   | 5.20                    | 2.40              | .0014    | .0280       | .0244      | .0036      | 0.64      | .0000       | .0000     | 1.0744           | 2.1       |
| 14306   | May 15              | Distinct.        | Cons., brown. | 1.50   | 7.05                    | 2.90              | .0030    | .0420       | .0360      | .0060      | 0.66      | .0030       | .0002     | 1.3983           | 2.3       |
| 14487   | June 18             | Decided.         | Cons., rusty. | 1.10   | 13.65                   | 3.40              | .0258    | .0522       | .0395      | .0124      | 1.90      | .0030       | .0000     | 1.0413           | 5.6       |
| 14658   | July 22             | Decided.         | Heavy, rusty. | 0.90   | 10.40                   | 2.75              | .0328    | .0460       | .0356      | .0104      | 1.60      | .0000       | .0002     | 0.9000           | 4.0       |
| 14893   | Aug 20              | Distinct.        | Cons., rusty. | 0.73   | 9.25                    | 2.85              | .0752    | .0362       | .0312      | .0050      | 1.42      | .0000       | .0001     | 0.6708           | 3.1       |
| 15188   | Sept. 17            | Slight.          | Slight.       | 0.70   | 11.65                   | 2.50              | .0684    | .0512       | .0482      | .0030      | 2.54      | .0030       | .0002     | 0.9826           | 5.1       |
| 15370   | Oct. 15             | Slight.          | Cons.         | 1.10   | 8.30                    | 3.95              | .0004    | .0504       | .0426      | .0078      | 0.88      | .0120       | .0003     | 1.3533           | 2.5       |
| 15590   | Nov. 19             | Slight.          | Slight.       | 1.30   | 6.80                    | 3.00              | .0018    | .0282       | .0266      | .0016      | 0.71      | .0070       | .0001     | 1.3338           | 1.9       |
| 15759   | Dec. 17             | Slight.          | Slight.       | 1.15   | 6.75                    | 3.10              | .0022    | .0244       | .0232      | .0012      | 0.64      | .0220       | .0002     | 1.0202           | 1.8       |
| Av.     | .....               | .....            | .....         | 1.04   | 8.40                    | 2.81              | .0182    | .0365       | .0312      | .0053      | 1.18      | .0064       | .0001     | 1.0458           | 3.0       |

## Averages by Years.

|   |       |   |   |      |       |      |       |       |       |       |      |       |       |        |     |
|---|-------|---|---|------|-------|------|-------|-------|-------|-------|------|-------|-------|--------|-----|
| - | 1887* | - | - | 1.19 | 8.35  | 2.30 | .0053 | .0400 | -     | -     | 0.99 | .0080 | -     | -      | -   |
| - | 1888  | - | - | 1.02 | 6.77  | 2.27 | .0030 | .0324 | -     | -     | 0.83 | .0095 | .0002 | -      | -   |
| - | 1891† | - | - | 1.48 | 10.34 | 3.45 | .0190 | .0510 | .0413 | .0097 | 1.16 | .0065 | .0003 | -      | 3.3 |
| - | 1892‡ | - | - | 0.90 | 13.30 | 2.85 | .0260 | .0324 | .0286 | .0038 | 2.31 | .0090 | .0012 | -      | 4.4 |
| - | 1893  | - | - | 1.16 | 7.70  | 2.49 | .0151 | .0320 | .0254 | .0066 | 1.19 | .0154 | .0005 | 0.9548 | 2.4 |
| - | 1894  | - | - | 1.14 | 9.68  | 2.69 | .0112 | .0360 | .0277 | .0083 | 1.64 | .0062 | .0002 | 1.0003 | 3.0 |
| - | 1895  | - | - | 1.04 | 8.40  | 2.81 | .0182 | .0665 | .0312 | .0053 | 1.18 | .0064 | .0001 | 1.0458 | 3.0 |

\* June to December.

† August and September.

‡ July.

NOTE to analyses of 1895: Odor, generally decidedly vegetable and musty or disagreeable, and occasionally offensive. — The samples were collected from the river, opposite the works of the Hyde Park Water Company. The river is not used directly as a source of water supply.

**HYDE PARK AND MILTON.***Microscopical Examination of Water from the Neponset River at Hyde Park.*

[Number of organisms per cubic centimeter.]

|                             | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|-----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                             | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .   | 15    | 20    | 19    | 17    | 16    | 19    | 23    | 22    | 18    | 17    | 21    | 20    |
| Number of sample, . . .     | 13658 | 18834 | 13992 | 14148 | 14306 | 14487 | 14658 | 14893 | 15185 | 15370 | 15580 | 15759 |
| <b>PLANTS.</b>              |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . .         | 7     | 2     | 7     | 67    | 85    | 21    | 4     | 28    | 2     | 88    | 4     | 1     |
| Asterionella, . . . .       | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 16    | 0     | 0     |
| Ceratonella, . . . .        | 0     | 0     | 0     | 3     | 5     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Cyclotella, . . . .         | 0     | 1     | 0     | 0     | 17    | 12    | 0     | 7     | 0     | 6     | 0     | 0     |
| Diatoma, . . . .            | 1     | 0     | 0     | 1     | 1     | 0     | 0     | 1     | 0     | 6     | 0     | 0     |
| Fragilaria, . . . .         | 0     | 0     | 0     | 0     | 2     | 0     | 4     | 0     | 0     | 0     | 0     | 0     |
| Melosira, . . . .           | 0     | 0     | 0     | 4     | 12    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Navicula, . . . .           | 1     | 1     | 0     | 1     | 5     | 1     | 0     | 0     | 1     | 4     | 3     | 0     |
| Synedra, . . . .            | 3     | 0     | 6     | 46    | 36    | 8     | 0     | 20    | 1     | 56    | 1     | 1     |
| Tabellaria, . . . .         | 2     | 0     | 1     | 10    | 7     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Cyanophyceæ, Microcystis, . | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 2     | 0     | 2     | 0     | 0     |
| Algeæ, . . . .              | 0     | 0     | 1     | 2     | 15    | 2     | 14    | 50    | 0     | 12    | 0     | 0     |
| Gloeocapsa, . . . .         | 0     | 0     | 0     | 0     | 4     | 0     | 0     | 12    | 0     | 0     | 0     | 0     |
| Proteococcus, . . . .       | 0     | 0     | 1     | 0     | 0     | 0     | 14    | 22    | 0     | 0     | 0     | 0     |
| Raphidium, . . . .          | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 8     | 0     | 0     |
| Scenedesmus, . . . .        | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 12    | 0     | 2     | 0     | 0     |
| Zoospores, . . . .          | 0     | 0     | 0     | 2     | 9     | 0     | 0     | 4     | 0     | 2     | 0     | 0     |
| Fungi, Crenothrix, . . .    | 44    | 140   | 5     | 8     | 608   | 484   | 9,600 | 56    | 44    | 30    | 228   | 7     |
| <b>ANIMALS.</b>             |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . . .          | 2     | 0     | 3     | 12    | 8     | 0     | 14    | 44    | 1     | 8     | 0     | 0     |
| Dinobryon, . . . .          | 0     | 0     | 0     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, . . . .    | 0     | 0     | 0     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Monas, . . . .              | 0     | 0     | 0     | 1     | 1     | 0     | 0     | 24    | 0     | 4     | 0     | 0     |
| Peridinium, . . . .         | 2     | 0     | 3     | 4     | 1     | 0     | 6     | 13    | 1     | 0     | 0     | 0     |
| Phacus, . . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     |
| Trachelomonas, . . . .      | 0     | 0     | 0     | 1     | 7     | 0     | 8     | 7     | 0     | 2     | 0     | 0     |
| Vermes, Rotifer, . . .      | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     |
| Miscellaneous, Zoöglæa, . . | 184   | 1,440 | 26    | 60    | 68    | 840   | 0     | 48    | 96    | 120   | 60    | 60    |
| TOTAL, . . . .              | 237   | 1,582 | 42    | 147   | 785   | 1,340 | 9,632 | 228   | 143   | 262   | 292   | 88    |

IPSWICH.

## WATER SUPPLY OF IPSWICH.

*Chemical Examination of Water from Dow's Brook above the Storage Reservoir of the Ipswich Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------|--------|-------------------------|-------------------|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                   |        |                         |                   |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |           |
| 13604   | 1893.<br>Jan. 5     | V. slight.  | V. slight.        | 0.37   | 4.15                    | 1.20              | .0002    | .0230       | .0162      | .0068           | .58       | .0040       | .0000     | .2707            | 1.9       |
| 13699   | Jan. 22             | Slight.     | Cons.,<br>dark.   | 0.70   | 4.70                    | 1.75              | .0005    | .0142       | .0124      | .0018           | .65       | .0030       | .0000     | .6399            | 1.4       |
| 13882   | Feb. 25             | None.       | Slight.           | 0.80   | 4.90                    | 1.05              | .0000    | .0098       | .0080      | .0018           | .62       | .0080       | .0000     | .3334            | 1.8       |
| 14054   | Mar. 29             | V. slight.  | Cons.             | 0.60   | 4.05                    | 1.35              | .0000    | .0135       | .0120      | .0018           | .59       | .0030       | .0000     | .5274            | 1.3       |
| 14210   | Apr. 24             | V. slight.  | Slight.           | 0.53   | 4.00                    | 1.80              | .0004    | .0102       | .0092      | .0010           | .60       | .0000       | .0001     | .5293            | 1.3       |
| 14372   | May 27              | V. slight.  | Slight,<br>brown. | 0.53   | 5.00                    | 1.60              | .0000    | .0120       | .0104      | .0016           | .61       | .0030       | .0000     | .5130            | 1.7       |
| 14530   | June 24             | Slight.     | Slight,<br>dark.  | 0.12   | 5.00                    | 1.25              | .0012    | .0062       | .0056      | .0006           | .58       | .0080       | .0000     | .1679            | 1.8       |
| 14921   | Aug. 23             | Distinct.   | Slight.           | 0.20   | 5.40                    | 1.75              | .0006    | .0082       | .0068      | .0014           | .64       | .0130       | .0005     | .2106            | 1.8       |
| 15266   | Sept. 25            | Slight.     | Slight.           | 0.22   | 5.30                    | 1.75              | .0020    | .0250       | .0230      | .0020           | .79       | .0030       | .0000     | .3744            | 1.8       |
| 15449   | Oct. 30             | V. slight.  | V. slight.        | 0.28   | 4.65                    | 1.75              | .0000    | .0076       | .0064      | .0012           | .62       | .0000       | .0000     | .3416            | 2.3       |
| 15616   | Nov. 26             | V. slight.  | Slight.           | 1.00   | 4.75                    | 2.15              | .0000    | .0150       | .0116      | .0034           | .54       | .0020       | .0000     | .8151            | 1.4       |
| 15800   | Dec. 23             | V. slight.  | V. slight.        | 0.90   | 4.70                    | 1.90              | .0004    | .0152       | .0142      | .0010           | .52       | .0030       | .0000     | .7430            | 1.3       |
| Avg.*   | .....               | .....       | .....             | 0.47   | 4.74                    | 1.62              | .0005    | .0129       | .0111      | .0018           | .61       | .0042       | .0001     | .4555            | 1.6       |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

Odor, generally faintly vegetable, sometimes none. The samples which had no odor when cold had vegetable odors when heated, and in the others the odors became stronger and sometimes also mouldy on eating — The samples were collected from the brook at its entrance to the storage reservoir.

*Microscopical Examination.*

The average number of organisms per cubic centimeter found in these samples was 42.



## IPSWICH.

*Chemical Examination of Water from the Dow's Brook Storage Reservoir of the Ipswich Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|------------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.       | Sediment.       | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                  |                 |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13805   | 1895.<br>Jan. 5     | Distinct, milky. | Slight.         | 1.00   | 8.05                    | 2.35              | .0000    | .0272       | .0232      | .0040      | 1.04      | .0200       | .0003     | .8190            | 2.9       |
| 13700   | Jan. 22             | Slight, milky.   | None.           | 0.62   | 6.30                    | 1.95              | .0006    | .0172       | .0146      | .0026      | 0.97      | .0100       | .0000     | .5609            | 2.2       |
| 13981   | Feb. 25             | V. slight        | V. slight.      | 0.55   | 5.45                    | 1.55              | .0008    | .0178       | .0172      | .0006      | 0.88      | .0150       | .0001     | .5411            | 2.1       |
| 14055   | Mar. 29             | Slight.          | Slight.         | 0.45   | 4.20                    | 1.50              | .0010    | .0158       | .0136      | .0022      | 0.69      | .0090       | .0000     | .4605            | 1.4       |
| 14211   | Apr. 24             | Distinct.        | Cons. white.    | 0.45   | 4.20                    | 1.80              | .0008    | .0146       | .0120      | .0026      | 0.67      | .0070       | .0002     | .5253            | 1.4       |
| 14373   | May 27              | Slight.          | Cons.           | 0.50   | 5.35                    | 2.20              | .0014    | .0180       | .0156      | .0024      | 0.70      | .0050       | .0003     | .5191            | 1.6       |
| 14531   | June 24             | Slight.          | Slight, yellow. | 0.25   | 5.10                    | 1.75              | .0030    | .0170       | .0152      | .0018      | 0.76      | .0000       | .0000     | .4297            | 1.7       |
| 14727   | July 19             | Slight.          | Cons.           | 0.25   | 5.10                    | 1.85              | .0010    | .0180       | .0168      | .0012      | 0.82      | .0100       | .0000     | .3850            | 2.5       |
| 14922   | Aug 28              | Slight.          | Slight.         | 0.18   | 5.25                    | 2.65              | .0014    | .0206       | .0170      | .0036      | 0.80      | .0000       | .0001     | .3276            | 1.9       |
| 15267   | Sept. 25            | V. slight        | Slight.         | 0.12   | 5.30                    | 1.80              | .0022    | .0258       | .0196      | .0062      | 0.78      | .0030       | .0000     | .3549            | 2.1       |
| 15450   | Oct. 30             | Slight.          | Slight.         | 0.30   | 5.45                    | 1.60              | .0040    | .0276       | .0258      | .0018      | 0.78      | .0070       | .0001     | .4758            | 1.9       |
| 15617   | Nov. 26             | Slight.          | Slight.         | 0.90   | 5.55                    | 2.15              | .0030    | .0194       | .0174      | .0020      | 0.66      | .0080       | .0001     | .7660            | 1.7       |
| 15801   | Dec. 23             | Slight.          | Slight.         | 0.60   | 4.90                    | 1.70              | .0014    | .0162       | .0140      | .0022      | 0.60      | .0070       | .0001     | .5425            | 1.6       |
| Av.*    | .....               | .....            | .....           | 0.45   | 5.25                    | 1.80              | .0022    | .0194       | .0169      | .0025      | 0.76      | .0072       | .0001     | .5015            | 1.9       |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

Odor, generally vegetable, often also mouldy or unpleasant, seldom none. On heating, frequently stronger and mouldy or unpleasant. — The samples were collected from the reservoir.

When this reservoir was filled, in November, 1894, about 10,000,000 gallons of water from Bull Brook were diverted into it.

*Microscopical Examination of Water from the Storage Reservoir of the Ipswich Water Works on Dow's Brook.*

[Number of organisms per cubic centimeter.]

| Day of examination, . . . | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                           | Jan.  | Jan.  | Feb.  | Apr.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Nov.  | Nov.  |
|                           | 8     | 23    | 28    | 2     | 26    | 28    | 25    | 31    | 29    | 28    | 1     | 27    |
| Number of sample, . . .   | 13805 | 13700 | 13881 | 14055 | 14211 | 14373 | 14531 | 14727 | 14922 | 15267 | 15450 | 15617 |
|                           |       |       |       |       |       |       |       |       |       |       |       |       |
| PLANTS.                   |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .         | 0     | 0     | 0     | 1     | 73    | 128   | 13    | 2     | 0     | 0     | 3     | 0     |
| Cyclotella, . . .         | 0     | 0     | 0     | 0     | 1     | 0     | 8     | 0     | 0     | 0     | 0     | 0     |
| Synedra, . . .            | 0     | 0     | 0     | 1     | 72    | 128   | 5     | 2     | 0     | 0     | 3     | 0     |
| Algæ, Protococcus, . .    | 0     | 1     | 0     | 5     | 2     | 0     | 3     | 0     | 7     | 3     | 0     | 0     |
| Fungi, Crenothrix, . .    | 0     | 2     | 0     | 4     | 1     | 132   | 0     | 0     | 0     | 2     | 19    | 1     |

## IPSWICH.

*Microscopical Examination of Water from the Storage Reservoir of the Ipswich Water Works on Dow's Brook—Concluded.*

[Number of organisms per cubic centimeter.]

|                           | 1895. |      |     |      |      |      |       |       |      |       |      |      |      |
|---------------------------|-------|------|-----|------|------|------|-------|-------|------|-------|------|------|------|
|                           | Jan.  | Jan. | Feb | Apr. | Apr. | May. | June. | July. | Aug. | Sept. | Nov. | Nov. | Dec. |
| ANIMALS.                  |       |      |     |      |      |      |       |       |      |       |      |      |      |
| Infusoria, . . . .        | 28    | 7    | 69  | 16   | 122  | 361  | 0     | 526   | 300  | 2     | 0    | 0    | 2    |
| Cryptomonas, . . . .      | 1     | 1    | 0   | 0    | 0    | 0    | 0     | 0     | 0    | 0     | 0    | 0    | 0    |
| Dinobryon, . . . .        | 0     | 0    | 54  | 0    | 0    | 0    | 0     | 498   | 0    | 0     | 0    | 0    | 2    |
| Dinobryon cases, . . .    | 18    | 6    | 14  | 12   | 116  | 360  | 0     | 28    | 0    | 0     | 0    | 0    | 0    |
| Peridinium, . . . .       | 9     | 0    | 1   | 4    | 6    | 1    | 0     | 0     | 300  | 2     | 0    | 0    | 0    |
| Vermes, Rotatorian ova, . | 0     | 0    | 0   | 0    | 0    | 0    | 0     | 0     | 4    | 0     | 0    | 0    | 0    |
| Crustacea, Cyclops, . .   | 0     | 0    | 0   | 0    | 0    | 0    | 0     | 0     | .04  | 0     | 0    | .04  | 0    |
| TOTAL, . . . .            | 28    | 10   | 69  | 26   | 198  | 621  | 16    | 528   | 311  | 7     | 22   | 1    | 2    |

*Chemical Examination of Water from Bull Brook, Ipswich.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 14053   | 1895.<br>Mar. 29    | V. slight.  | V. slight. | 1.25   | 5.20                    | 2.40              | .0004    | .0216       | .0294      | .0012      | .60       | .0090       | .0000     | 1.0433           | 1.6       |

Odor, distinctly vegetable, becoming stronger on heating. — The sample was collected from the brook, a short distance above its junction with Dow's Brook.

*Microscopical Examination.*

Diatomaceæ, *Melosira*, 3; *Meridion*, 9; *Synedra*, 3. Fungi, *Crenothrix*, 82. Total, 47.

*Chemical Examination of Water from Faucets supplied from Ipswich Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|--------------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.         | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                    |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 13883   | 1895.<br>Feb. 25    | Decided,<br>milky. | V. slight. | .73    | 9.05                            | 2.45                 | .0032    | .0228       | .0216      | .0012           | .97       | .0200          | .0003     | .7252            | 2.9       |
| 14212   | Apr. 24             | Slight,<br>milky.  | V. slight. | .47    | 6.55                            | 1.95                 | .0014    | .0132       | .0120      | .0012           | .78       | .0170          | .0003     | .4558            | 2.6       |

Odor of the first sample, none, becoming distinctly vegetable and somewhat unpleasant on heating; of the second sample, faintly vegetable, becoming stronger and mouldy on heating. — The samples were collected from faucets in the town.

*Microscopical Examination.*

No. 13883. Miscellaneous, *Zoëglæa*, 26.

No. 14212. Diatomaceæ, *Synedra*, 8. Algae, *Protococcus*, 1. Fungi, *Crenothrix*, 1. Infusoria, *Peridinium*, 1. Total, 11.

## IPSWICH.

*Chemical Examination of Water from a Spring in Ipswich.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Alb.-minhold. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | 1895.               |             |           |        |                         |          |               |           |             |           |                  |           |       |
| 14371   | May 27              | None.       | None.     | .00    | 4.25                    | .0000    | .0006         | .94       | .0550       | .0000     | .0228            | 2.7       | .0000 |
| 14726   | July 29             | V. slight   | Slight.   | .03    | 6.55                    | .0000    | .0014         | .94       | .0700       | .0000     | .0289            | 3.5       | .0000 |

Odor, none. — The samples were collected from a spring, located very near Dow's Brook, about 500 feet above the upper end of the Dow's Brook storage reservoir.

*Microscopical Examination.*

No. 14371. Diatomaceæ, *Meridion*, 6.

No. 14726. No organisms.

## WATER SUPPLY OF KINGSTON.

The advice of the State Board of Health to the town of Kingston with reference to the use of lead pipes in the distribution of the water supplied to the town may be found on pages 30 to 32 of this volume.

*Chemical Examination of Water from a Faucet supplied from the Kingston Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Alb.-minhold. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | 1895.               |             |            |        |                         |          |               |           |             |           |                  |           |       |
| 14763   | Aug. 5              | None.       | V. slight. | .02    | 5.10                    | .0008    | .0016         | .76       | .0730       | .0019     | .0624            | 1.8       | .0050 |

Odor, very faintly vegetable.

*Microscopical Examination.*

Fungi, *Crenothrix*, 3.

## WATER SUPPLY OF LAWRENCE.

The following tables contain analyses of the unfiltered Merrimack River water, and of the filtered water at the pumping station and at the distributing reservoir. The results of more extended chemical and biological examinations of the water before and after filtration through the sand filter may be found in a subsequent portion of this report.

## LAWRENCE.

*Chemical Examination of Water from the Merrimack River above Lawrence, opposite the Intake of the Lawrence Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |                    |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|--------------------|--------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.         | Sediment.          | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                    |                    |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 13677   | 1895.<br>Jan. 16    | Slight.            | V. slight.         | .40    | 4.70                            | 1.40                 | .0124    | .0224       | .0198      | .0026           | .35       | .0070          | .0001     | .4740            | 1.4       |
| 13862   | Feb. 20             | Distinct.          | Slight.            | .45    | 4.95                            | 1.50                 | .0108    | .0238       | .0186      | .0052           | .35       | .0100          | .0003     | .5070            | 1.6       |
| 14019   | Mar. 20             | Distinct.          | Cons.,<br>floc.    | .55    | 4.35                            | 1.65                 | .0020    | .0276       | .0196      | .0080           | .22       | .0050          | .0002     | .6320            | 1.4       |
| 14168   | Apr. 17             | Decided.           | Heavy,<br>earthy   | .55    | 3.25                            | 1.60                 | .0052    | .0306       | .0146      | .0160           | .29       | .0030          | .0001     | .6399            | 0.5       |
| 14340   | May 21              | Distinct.          | Slight.            | .58    | 3.70                            | 1.25                 | .0026    | .0220       | .0162      | .0058           | .23       | .0070          | .0001     | .6478            | 1.3       |
| 14496   | June 19             | Decided.           | Cons.,<br>brown    | .40    | 4.25                            | 2.15                 | .0060    | .0320       | .0174      | .0146           | .26       | .0050          | .0004     | .4602            | 1.3       |
| 14695   | July 24             | Slight.            | Cons.              | .42    | 4.10                            | 1.25                 | .0094    | .0236       | .0176      | .0060           | .36       | .0070          | .0003     | .4928            | 1.8       |
| 14888   | Aug 21              | Distinct.          | Slight.            | .25    | 4.45                            | 1.90                 | .0128    | .0212       | .0182      | .0030           | .30       | .0030          | .0002     | .4056            | 1.6       |
| 15206   | Sept. 18            | Distinct.          | Slight.            | .28    | 4.90                            | 1.65                 | .0108    | .0208       | .0176      | .0032           | .40       | .0050          | .0005     | .3822            | 1.8       |
| 15384   | Oct. 16             | Slight,<br>milky.  | Slight,<br>earthy. | .90    | 4.95                            | 2.50                 | .0016    | .0302       | .0250      | .0052           | .29       | .0130          | .0002     | .9766            | 1.7       |
| 15382   | Nov. 20             | Distinct.          | Cons.              | .90    | 4.05                            | 2.40                 | .0000    | .0226       | .0206      | .0020           | .22       | .0070          | .0001     | .9048            | 0.8       |
| 15771   | Dec. 18             | Slight,<br>clayey. | Slight.            | .48    | 4.45                            | 1.70                 | .0028    | .0218       | .0170      | .0048           | .12       | .0130          | .0002     | .5621            | 1.1       |
| Av.     | .....               | .....              | .....              | .51    | 4.34                            | 1.75                 | .0064    | .0249       | .0185      | .0064           | .28       | .0071          | .0002     | .5904            | 1.4       |

## Averages by Years.

|   |       |   |   |     |       |       |       |       |       |       |     |       |       |       |      |
|---|-------|---|---|-----|-------|-------|-------|-------|-------|-------|-----|-------|-------|-------|------|
| - | 1887* | - | - | .47 | 4.82  | 1.24  | .0027 | .0211 | -     | -     | .22 | .0097 | -     | -     | -    |
| - | 1888  | - | - | .30 | 3.68  | 1.08  | .0026 | .0180 | -     | -     | .18 | .0094 | .0002 | -     | -    |
| - | 1889  | - | - | .30 | 3.09† | 0.87† | .0030 | .0176 | .0144 | .0032 | .17 | .0072 | .0003 | -     | -    |
| - | 1890  | - | - | .33 | 4.19‡ | 1.48‡ | .0046 | .0166 | .0132 | .0034 | .17 | .0089 | .0001 | -     | 1.6‡ |
| - | 1891  | - | - | .27 | 3.79  | 1.32  | .0040 | .0152 | .0121 | .0031 | .18 | .0110 | .0001 | -     | 1.3  |
| - | 1892  | - | - | .43 | 4.12  | 1.47  | .0042 | .0181 | .0152 | .0029 | .18 | .0105 | .0001 | -     | 1.4  |
| - | 1893  | - | - | .42 | 3.86  | 1.48  | .0057 | .0181 | .0141 | .0040 | .20 | .0081 | .0002 | .5295 | 1.1  |
| - | 1894  | - | - | .37 | 3.70  | 1.30  | .0062 | .0167 | .0141 | .0026 | .23 | .0065 | .0001 | .4370 | 1.2  |
| - | 1895  | - | - | .51 | 4.34  | 1.75  | .0064 | .0249 | .0185 | .0064 | .28 | .0071 | .0002 | .5904 | 1.4  |

\* June to November. † January to May. ‡ August to December. § July to December.

**NOTE** to analyses of 1895: Odor, until May, decidedly musty and disagreeable; during the remainder of the year, distinctly vegetable and frequently also musty or unpleasant. — The samples are collected from the river, opposite the intake of the Lawrence water works, about 1 foot beneath surface. For a record of the quantity of water flowing in the river on dates when samples of water are collected for analysis, see page 195. For a comparison of the analyses of the river water at Lowell & Lawrence for a series of years, see "Merrimack River" in the chapter on "Examination of Rivers."

**LAWRENCE.**

*Microscopical Examination of Water from the Merrimack River above Lawrence, opposite the Intake of the Lawrence Water Works.*

[Number of organisms per cubic centimeter.]

|                               | 1895.      |            |            |           |            |              |              |            |            |            |            |           |
|-------------------------------|------------|------------|------------|-----------|------------|--------------|--------------|------------|------------|------------|------------|-----------|
|                               | Jan.       | Feb.       | Mar.       | Apr.      | May.       | June.        | July.        | Aug.       | Sept.      | Oct.       | Nov.       | Dec.      |
| Day of examination, . . . .   | 17         | 22         | 21         | 18        | 23         | 20           | 26           | 22         | 21         | 17         | 21         | 20        |
| Number of sample, . . . .     | 13677      | 13862      | 14019      | 14168     | 14340      | 14496        | 14698        | 14888      | 15206      | 15384      | 15582      | 15771     |
| <b>PLANTS.</b>                |            |            |            |           |            |              |              |            |            |            |            |           |
| Diatomaceæ, . . . .           | 4          | 1          | 4          | 32        | 317        | 1,095        | 314          | 503        | 2          | 53         | 16         | 2         |
| Asterionella, . . . .         | 0          | 0          | 2          | 0         | 0          | 0            | 4            | 15         | 0          | 1          | 0          | 0         |
| Cyclotella, . . . .           | 0          | 0          | 0          | 0         | 0          | 1            | 0            | 10         | 0          | 0          | 0          | 0         |
| Diatoma, . . . .              | 0          | 0          | 0          | 4         | 2          | 0            | 0            | 0          | 2          | 0          | 0          | 0         |
| Fragilaria, . . . .           | 0          | 0          | 0          | 0         | 0          | 4            | 1            | 68         | 0          | 2          | 0          | 0         |
| Melosira, . . . .             | 0          | 0          | 0          | 0         | 0          | 0            | 13           | 2          | 0          | 10         | 0          | 0         |
| Navicula, . . . .             | 0          | 0          | 1          | 4         | 0          | 8            | 6            | 3          | 0          | 1          | 1          | 0         |
| Pinnularia, . . . .           | 0          | 0          | 0          | 0         | 0          | 10           | 2            | 2          | 0          | 3          | 1          | 0         |
| Synedra, . . . .              | 4          | 1          | 1          | 22        | 312        | 1,000        | 272          | 392        | 0          | 36         | 2          | 2         |
| Tabellaria, . . . .           | 0          | 0          | 0          | 2         | 3          | 72           | 16           | 11         | 0          | 0          | 12         | 0         |
| Cyanophyceæ, . . . .          | 0          | 0          | 0          | 2         | 0          | 21           | 5            | 0          | 2          | 3          | 0          | 0         |
| Microcystis, . . . .          | 0          | 0          | 0          | 0         | 0          | 21           | 5            | 0          | 0          | 0          | 0          | 0         |
| Oscillaria, . . . .           | 0          | 0          | 0          | 2         | 0          | 0            | 0            | 0          | 2          | 3          | 0          | 0         |
| Algæ, . . . .                 | 1          | 0          | 0          | 0         | 30         | 554          | 792          | 193        | 0          | 0          | 0          | 0         |
| Glaucopæa, . . . .            | 0          | 0          | 0          | 0         | 0          | 0            | 32           | 1          | 0          | 0          | 0          | 0         |
| Protococcus, . . . .          | 1          | 0          | 0          | 0         | 17         | 540          | 364          | 188        | 0          | 0          | 0          | 0         |
| Raphidium, . . . .            | 0          | 0          | 0          | 0         | 10         | 6            | 40           | 0          | 0          | 0          | 0          | 0         |
| Scenedesmus, . . . .          | 0          | 0          | 0          | 0         | 3          | 8            | 24           | 4          | 0          | 0          | 0          | 0         |
| Selenastrum, . . . .          | 0          | 0          | 0          | 0         | 0          | 0            | 332          | 0          | 0          | 0          | 0          | 0         |
| Fungi, Crenothrix, . . . .    | 7          | 44         | 6          | 12        | 68         | 17           | 40           | 4          | 104        | 28         | 24         | 0         |
| <b>ANIMALS.</b>               |            |            |            |           |            |              |              |            |            |            |            |           |
| Infusoria, . . . .            | 2          | 0          | 10         | 0         | 9          | 0            | 12           | 4          | 0          | 1          | 0          | 0         |
| Dinobryon cases, . . . .      | 0          | 0          | 10         | 0         | 3          | 0            | 7            | 0          | 0          | 0          | 0          | 0         |
| Euglena, . . . .              | 1          | 0          | 0          | 0         | 1          | 0            | 0            | 0          | 0          | 0          | 0          | 0         |
| Paramæcium, . . . .           | 0          | 0          | 0          | 0         | 1          | 0            | 1            | 0          | 0          | 0          | 0          | 0         |
| Peridinium, . . . .           | 0          | 0          | 0          | 0         | 0          | 0            | 4            | 3          | 0          | 0          | 0          | 0         |
| Trachelomonas, . . . .        | 1          | 0          | 0          | 0         | 2          | 0            | 0            | 1          | 0          | 1          | 0          | 0         |
| Vermes, . . . .               | 0          | 0          | 0          | 0         | 0          | 3            | 0            | 4          | 0          | 0          | 0          | 0         |
| Anurea, . . . .               | 0          | 0          | 0          | 0         | 0          | 3            | 0            | 0          | 0          | 0          | 0          | 0         |
| Rotatorian ova, . . . .       | 0          | 0          | 0          | 0         | 0          | 0            | 0            | 4          | 0          | 0          | 0          | 0         |
| Miscellaneous, Zoöglæa, . . . | 128        | 120        | 88         | 0         | 536        | 0            | 0            | 216        | 0          | 200        | 100        | 20        |
| <b>TOTAL, . . . .</b>         | <b>142</b> | <b>165</b> | <b>108</b> | <b>46</b> | <b>960</b> | <b>1,690</b> | <b>1,163</b> | <b>924</b> | <b>108</b> | <b>285</b> | <b>140</b> | <b>22</b> |

LAWRENCE.

*Chemical Examination of Water from the Force Main at the Pumping Station of the Lawrence Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |             |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Sus-pended. |           |             |           |                  |           |
| 1895.   |                     |             |            |        |                         |                   |          |             |            |             |           |             |           |                  |           |
| 13678   | Jan. 16             | V. slight.  | V. slight. | 0.43   | 5.80                    | 1.25              | .0156    | .0136       | .0126      | .0010       | .36       | .0150       | .0000     | .3571            | 2.5       |
| 13863   | Feb. 20             | None.       | V. slight  | 0.60   | 7.60                    | 1.40              | .0278    | .0098       | .0084      | .0014       | .39       | .0300       | .0001     | .2847            | 3.5       |
| 14020   | Mar. 20             | V. slight.  | V. slight. | 0.58   | 5.50                    | 1.80              | .0136    | .0144       | .0130      | .0014       | .26       | .0070       | .0001     | .4558            | 2.5       |
| 14169   | Apr. 17             | V. slight.  | Slight     | 0.70   | 6.95                    | 1.90              | .0328    | .0084       | .0072      | .0012       | .14       | .0450       | .0000     | .3278            | 3.8       |
| 14341   | May 21              | V. slight.  | V. slight. | 0.48   | 5.40                    | 1.50              | .0090    | .0098       | .0086      | .0012       | .27       | .0450       | .0001     | .4187            | 2.7       |
| 14497   | June 19             | Distinct.   | Slight.    | 0.40   | 6.90                    | 2.60              | .0152    | .0086       | .0060      | .0026       | .34       | .0350       | .0003     | .2418            | 2.9       |
|         |                     |             | rusty.     |        |                         |                   |          |             |            |             |           |             |           |                  |           |
| 14699   | July 24             | V. slight.  | V. slight. | 0.33   | 4.00                    | 1.10              | .0042    | .0098       | .0090      | .0008       | .36       | .0170       | .0000     | .3465            | 2.1       |
| 14889   | Aug 21              | Distinct.   | Slight.    | 0.35   | 6.55                    | 1.70              | .0088    | .0082       | .0074      | .0008       | .37       | .0420       | .0000     | .1950            | 3.0       |
|         |                     |             | milky.     |        |                         |                   |          |             |            |             |           |             |           |                  |           |
|         |                     |             | rusty.     |        |                         |                   |          |             |            |             |           |             |           |                  |           |
| 15207   | Sept 18             | Slight.     | Slight.    | 0.23   | 5.20                    | 1.30              | .0050    | .0086       | .0074      | .0012       | .36       | .0150       | .0001     | .2379            | 2.2       |
|         |                     |             | rusty.     |        |                         |                   |          |             |            |             |           |             |           |                  |           |
| 15385   | Oct. 16             | V. slight.  | Slight.    | 0.45   | 6.20                    | 2.20              | .0128    | .0126       | .0106      | .0020       | .41       | .0300       | .0000     | .4095            | 3.0       |
|         |                     |             | milky.     |        |                         |                   |          |             |            |             |           |             |           |                  |           |
| 15583   | Nov. 20             | V. slight.  | V. slight. | 1.00   | 6.55                    | 1.80              | .0226    | .0118       | .0106      | .0012       | .31       | .0300       | .0000     | .5616            | 3.0       |
| 15772   | Dec. 18             | V. slight.  | V. slight. | 0.45   | 4.80                    | 1.90              | .0076    | .0138       | .0122      | .0016       | .20       | .0180       | .0000     | .4735            | 1.4       |
|         |                     |             | clayey.    |        |                         |                   |          |             |            |             |           |             |           |                  |           |
| Av.     | 1895                | .....       | .....      | 0.50   | 5.95                    | 1.70              | .0146    | .0108       | .0094      | .0014       | .31       | .0274       | .0001     | .3592            | 2.7       |
| Av.     | 1894                | .....       | .....      | 0.39   | 6.10                    | 1.41              | .0103    | .0094       | .0081      | .0013       | .30       | .0309       | .0002     | .2910            | 2.8       |

NOTE to analyses of 1895: Odor, generally vegetable. — The samples were collected from a faucet in the check-valve just beyond the pump, and represent water from the river which has passed through the sand filter, mingled with a small amount of ground water.

*Microscopical Examination of Water from the Force Main at the Pumping Station of the Lawrence Water Works.*

[Number of organisms per cubic centimeter.]

|                                   | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|-----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                   | Jan.  | Feb.  | Mar.  | Apr.  | May   | June  | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . . .     | 17    | 22    | 21    | 18    | 23    | 20    | 26    | 22    | 21    | 17    | 21    | 20    |
| Number of sample, . . . . .       | 13678 | 13863 | 14020 | 14169 | 14341 | 14497 | 14699 | 14889 | 15207 | 15385 | 15583 | 15772 |
| <b>PLANTS.</b>                    |       |       |       |       |       |       |       |       |       |       |       |       |
| ungi, . . . . .                   | 154   | 66    | 136   | 86    | 268   | 520   | 44    | 396   | 63    | 0     | 1,080 | 0     |
| Crenothrix, . . . . .             | 154   | 66    | 136   | 86    | 268   | 520   | 38    | 396   | 52    | 0     | 1,080 | 0     |
| Molds, . . . . .                  | 0     | 0     | 0     | 0     | 0     | 0     | 6     | 0     | 11    | 0     | 0     | 0     |
| Accellaneous, Zooglaea, . . . . . | 0     | 0     | 0     | 0     | 56    | 0     | 0     | 16    | 0     | 2     | 0     | 0     |
| <b>TOTAL,</b> . . . . .           | 154   | 66    | 136   | 86    | 324   | 520   | 44    | 412   | 63    | 2     | 1,080 | 0     |

**LAWRENCE.***Chemical Examination of Water from the Distributing Reservoir of the Lawrence Water Works.*

[Parts per 100,000.]

| Number.  | Date of Collection. | APPEARANCE.        |            |        | RESIDUE ON EVAPORATION |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. |     | Hardness. |
|----------|---------------------|--------------------|------------|--------|------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----|-----------|
|          |                     | Turbidity.         | Sediment.  | Color. | Total.                 | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |     |           |
|          |                     |                    |            |        |                        |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |     |           |
| 1895.    |                     |                    |            |        |                        |                   |          |             |            |            |           |             |           |                  |     |           |
| 13679    | Jan. 16             | V. slight.         | None.      | .38    | 5.50                   | 1.50              | .0096    | .0144       | .0126      | .0018      | .34       | .0130       | .0000     | .3515            | 2.3 |           |
| 13864    | Feb. 20             | None.              | V. slight. | .32    | 5.55                   | 1.20              | .0106    | .0136       | .0122      | .0014      | .31       | .0200       | .0000     | .3526            | 2.2 |           |
| 14021    | Mar. 20             | V. slight.         | V. slight. | .28    | 5.65                   | 1.30              | .0098    | .0116       | .0094      | .0022      | .29       | .0220       | .0000     | .3634            | 2.3 |           |
| 14170    | Apr. 17             | V. slight.         | V. slight. | .27    | 4.85                   | 1.40              | .0084    | .0110       | .0084      | .0026      | .26       | .0250       | .0001     | .3792            | 2.3 |           |
| 14342    | May 21              | V. slight          | Slight.    | .30    | 4.85                   | 1.80              | .0090    | .0100       | .0086      | .0014      | .22       | .0300       | .0000     | .3713            | 1.7 |           |
| 14493    | June 19             | Slight.            | Slight.    | .25    | 4.55                   | 1.40              | .0010    | .0096       | .0084      | .0012      | .28       | .0220       | .0002     | .2769            | 1.7 |           |
| 14700    | July 24             | V. slight.         | Slight.    | .20    | 4.60                   | 1.50              | .0022    | .0094       | .0078      | .0016      | .36       | .0200       | .0001     | .2849            | 2.5 |           |
| 14890    | Aug. 21             | V. slight.         | V. slight  | .13    | 5.00                   | 1.95              | .0024    | .0092       | .0082      | .0010      | .32       | .0200       | .0002     | .2184            | 2.1 |           |
| 15208    | Sept. 18            | Slight.            | Slight.    | .18    | 4.85                   | 1.30              | .0018    | .0090       | .0088      | .0022      | .35       | .0220       | .0002     | .2574            | 2.1 |           |
| 15386    | Oct. 16             | V. slight.         | V. slight. | .15    | 4.80                   | 1.65              | .0018    | .0072       | .0058      | .0014      | .38       | .0300       | .0000     | .2340            | 1.9 |           |
| 15584    | Nov. 20             | V. slight.         | V. slight. | .50    | 4.90                   | 1.70              | .0068    | .0156       | .0138      | .0018      | .26       | .0120       | .0001     | .5148            | 2.2 |           |
| 15773    | Dec. 18             | V. slight, clayey. | Slight.    | .50    | 5.00                   | 1.95              | .0066    | .0104       | .0094      | .0010      | .18       | .0280       | .0001     | .5043            | 1.8 |           |
| Av. .... |                     |                    |            | .29    | 5.01                   | 1.55              | .0051    | .0109       | .0093      | .0016      | .30       | .0220       | .0001     | .3424            | 2.1 |           |

Odor, generally vegetable, often none. — Nos. 14700 and 14890 were collected from the reservoir; the other samples, from a faucet at the gate-house. The samples represent water flowing out of the reservoir. The reservoir is supplied with filtered water.

*Microscopical Examination of Water from the Distributing Reservoir of the Lawrence Water Works.*

[Number of organisms per cubic centimeter.]

|                               | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|-------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                               | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July  | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . . . | 17    | 23    | 21    | 18    | 23    | 20    | 26    | 22    | 21    | 17    | 21    | 20    |
| Number of sample, . . . . .   | 13679 | 13864 | 14021 | 14170 | 14342 | 14498 | 14700 | 14890 | 15208 | 15386 | 15584 | 15773 |
| <b>PLANTS.</b>                |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . . .         | 7     | 0     | 0     | 0     | 8     | 3     | 27    | 0     | 1,624 | 0     | 1     | 0     |
| Cyclotella, . . . . .         | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 1,560 | 0     | 0     | 0     |
| Synedra, . . . . .            | 7     | 0     | 0     | 0     | 7     | 3     | 27    | 0     | 64    | 0     | 1     | 0     |

LAWRENCE.

*Microscopical Examination of Water from the Distributing Reservoir of the Lawrence Water Works — Concluded.*

[Number of organisms per cubic centimeter.]

|                                   | 1895. |      |      |      |      |       |       |      |       |      |      |      |
|-----------------------------------|-------|------|------|------|------|-------|-------|------|-------|------|------|------|
|                                   | Jan.  | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
| <b>PLANTS — Con.</b>              |       |      |      |      |      |       |       |      |       |      |      |      |
| Algæ, . . . . .                   | 0     | 0    | 0    | 0    | 25   | 28    | 101   | 0    | 76    | 0    | 0    | 0    |
| Protozoans, . . . . .             | 0     | 0    | 0    | 0    | 25   | 25    | 100   | 0    | 0     | 0    | 0    | 0    |
| Raphidium, . . . . .              | 0     | 0    | 0    | 0    | 0    | 0     | 1     | 0    | 32    | 0    | 0    | 0    |
| Staurostrum, . . . . .            | 0     | 0    | 0    | 0    | 0    | 1     | 0     | 0    | 44    | 0    | 0    | 0    |
| Fungi, Crenothrix, . . . . .      | 16    | 24   | 2    | 600  | 52   | 28    | 7     | 16   | 7     | 2    | 20   | 0    |
| <b>ANIMALS.</b>                   |       |      |      |      |      |       |       |      |       |      |      |      |
| Infusoria, . . . . .              | 0     | pr.  | 2    | 4    | 0    | 0     | 1     | 1    | 10    | 0    | 0    | 0    |
| Dinobryon, . . . . .              | 0     | 0    | 2    | 0    | 0    | 0     | 0     | 0    | 0     | 0    | 0    | 0    |
| Dinobryon cases, . . . . .        | 0     | 0    | 0    | 4    | 0    | 0     | 0     | 0    | 0     | 0    | 0    | 0    |
| Peridinium, . . . . .             | 0     | pr.  | 0    | 0    | 0    | 0     | 1     | 1    | 10    | 0    | 0    | 0    |
| Miscellaneous, Zoöglæa, . . . . . | 1     | 0    | 230  | 0    | 0    | 0     | 0     | 54   | 18    | 0    | 0    | 0    |
| <b>TOTAL,</b> . . . . .           | 24    | 24   | 234  | 604  | 85   | 57    | 136   | 71   | 1,735 | 2    | 21   | 0    |

*Volume of Water flowing in the Merrimack River at Lawrence on the Dates when Samples of Water were collected for Analysis.*

| DATE.               | VOLUME FLOWING IN THE<br>MERRIMACK RIVER IN<br>CUBIC FEET PER SECOND. |                                                               | DATE.               | VOLUME FLOWING IN THE<br>MERRIMACK RIVER IN<br>CUBIC FEET PER SECOND. |                                                               |
|---------------------|-----------------------------------------------------------------------|---------------------------------------------------------------|---------------------|-----------------------------------------------------------------------|---------------------------------------------------------------|
|                     | Rate of<br>Flow during<br>Eleven<br>Hours of the<br>Day.              | Rate of<br>Flow during<br>the Whole<br>Twenty-<br>four Hours. |                     | Rate of<br>Flow during<br>Eleven<br>Hours of the<br>Day.              | Rate of<br>Flow during<br>the Whole<br>Twenty-<br>four Hours. |
| 1895.               |                                                                       |                                                               | 1895—Con.           |                                                                       |                                                               |
| Jan. 16, . . . . .  | 4,650                                                                 | 3,750                                                         | July 24, . . . . .  | 3,500                                                                 | 2,600                                                         |
| Feb. 20, . . . . .  | 2,820                                                                 | 1,800                                                         | Aug. 21, . . . . .  | 3,140                                                                 | 2,150                                                         |
| March 20, . . . . . | 8,600                                                                 | 7,750                                                         | Sept. 18, . . . . . | 3,210                                                                 | 2,250                                                         |
| April 17, . . . . . | 70,550                                                                | 70,550                                                        | Oct. 16, . . . . .  | 14,380                                                                | 13,500                                                        |
| May 21, . . . . .   | 5,410                                                                 | 4,600                                                         | Nov. 20, . . . . .  | 14,420                                                                | 13,550                                                        |
| Nov. 19, . . . . .  | 3,400                                                                 | 2,490                                                         | Dec. 18, . . . . .  | 6,400                                                                 | 5,580                                                         |

WATER SUPPLY OF LEICESTER.

The advice of the State Board of Health to the town of Leicester, relative to taking an additional supply of water from Asnebumskit and in the town of Paxton, may be found on pages 32 and 33 of



**LEICESTER.**

this volume. The results of an analysis of a sample of water from this source, collected in August, 1893, may be found under *Paxton* in this volume.

*Chemical Examination of Water from the Wells of the Leicester Water Supply District.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 13686   | 1895.<br>Jan. 17    | None.       | V. slight. | .47    | 6.20                    | .0000    | .0126       | .19       | .0500       | .0000     | .6019            | 2.5       | .0110 |
| 13951   | Mar. 11             | V. slight.  | V. slight. | .68    | 6.95                    | .0006    | .0154       | .18       | .0350       | .0000     | .7099            | 2.7       | .0060 |
| 14272   | May 10              | V. slight.  | V. slight  | .53    | 5.40                    | .0008    | .0118       | .17       | .0320       | .0001     | .5082            | 2.1       | .0140 |
| 14631   | July 16             | None.       | Slight.    | .60    | 5.55                    | .0000    | .0098       | .20       | .0470       | .0000     | .6552            | 2.1       | -     |
| 15169   | Sept. 16            | None.       | None.      | .25    | 5.20                    | .0000    | .0040       | .27       | .0600       | .0003     | .2691            | 1.9       | -     |
| 15539   | Nov. 11             | None.       | None.      | .03    | 4.60                    | .0000    | .0012       | .23       | .0500       | .0000     | .0546            | 1.8       | .0040 |
| Av.     | .....               | .....       | .....      | .43    | 5.65                    | .0002    | .0091       | .21       | .0457       | .0001     | .4665            | 2.2       | .0087 |

Odor of No. 13951, faintly vegetable; of the other samples, none. On heating, vegetable odors were developed in the first and last samples.—The samples were collected from a faucet in the village.

*Microscopical Examination.*

The average number of organisms per cubic centimeter found in these samples was 139.

**WATER SUPPLY OF LENOX.**

During the year 1895 the capacity of the reservoir on the brook tributary to the Williams River was increased and a line of pipe constructed, by which water is delivered to the town by gravity, instead of being pumped to the distributing reservoir as was formerly done. The present capacity of the reservoir is estimated to be about 20,000,000 gallons, its area about 7 acres and its depth from 6 to 30 feet. The reservoir was prepared for the storage of water by removing the soil from the bottom and sides.

**WATER SUPPLY OF LEOMINSTER.**

The advice of the State Board of Health to the town of Leominster with reference to taking Fall Brook in that town as an additional source of water supply may be found on pages 33-35 of this volume.

## LEOMINSTER.

A small dam has been constructed on the stream flowing from Haynes Reservoir, at a point about 1,500 feet below the reservoir, a pipe has been laid from this dam to Morse Reservoir, a distance of about 1,100 feet. By means of this dam and pipe line water drawn from Haynes Reservoir can be diverted into Morse Reservoir, and during the drier portion of 1895, beginning with the 1st of July, the water drawn from Haynes Reservoir was diverted to Morse Reservoir and flowed to the distributing reservoir from that latter source. The deterioration in the quality of the water of Morse Reservoir in 1895, indicated by the table of averages by years given below, was due to the diversion into it of water from Haynes Reservoir.

*Chemical Examination of Water from Morse Reservoir, Leominster.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |                  |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------------------|-------------|------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment.        | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|                     |             |                  |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.               |             |                  |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| Jan. 22             | Slight.     | Slight.          | 0.33   | 3.00                            | 1.25                 | .0256    | .0258       | .0224      | .0034           | .24       | .0030          | .0000     | .4740            | 0.8       |
| Mar. 20             | V. slight.  | Cons.            | 0.18   | 2.05                            | 0.55                 | .0010    | .0090       | .0078      | .0012           | .18       | .0030          | .0001     | .2725            | 0.0       |
| May 22              | V. slight.  | Slight.          | 0.20   | 2.40                            | 1.10                 | .0000    | .0104       | .0086      | .0018           | .16       | .0000          | .0000     | .3458            | 0.3       |
| July 30             | Distinct.   | Cons.            | 0.28   | 2.45                            | 1.25                 | .0002    | .0344       | .0204      | .0140           | .20       | .0070          | .0000     | .4774            | 0.3       |
| Sept. 24            | Distinct.   | Cons.,<br>green. | 0.37   | 3.65                            | 2.20                 | .0064    | .0424       | .0382      | .0062           | .23       | .0030          | .0000     | .4820            | 0.3       |
| Nov. 26             | Slight.     | Slight.          | 0.35   | 3.25                            | 2.05                 | .0308    | .0392       | .0326      | .0066           | .16       | .0080          | .0001     | .6240            | 0.3       |
| .....               | .....       | .....            | 0.28   | 2.80                            | 1.40                 | .0107    | .0269       | .0213      | .0055           | .18       | .0040          | .0000     | .4459            | 0.3       |

*Averages by Years.*

|       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| 1887* | - | - | 0.32 | 2.57 | 0.74 | .0010 | .0117 | -     | -     | .12 | .0028 | -     | -     | -   |
| 1888† | - | - | 0.13 | 1.98 | 0.58 | .0001 | .0065 | -     | -     | .09 | .0036 | .0000 | -     | -   |
| 1893  | - | - | 0.40 | 2.73 | 1.36 | .0009 | .0176 | .0135 | .0040 | .16 | .0032 | .0001 | .5156 | 0.5 |
| 1894  | - | - | 0.36 | 2.59 | 1.11 | .0026 | .0169 | .0128 | .0041 | .17 | .0017 | .0001 | .4052 | 0.2 |
| 1895  | - | - | 0.28 | 2.80 | 1.40 | .0107 | .0269 | .0213 | .0055 | .18 | .0040 | .0000 | .4459 | 0.3 |

\* June to December.

† February to May.

NOTE to analyses of 1895: Odor, vegetable. — The samples were collected from the reservoir, quality of the water of this reservoir was affected after the first of July by the diversion into it of water from Haynes reservoir.

**LEOMINSTER.***Microscopical Examination of Water from Morse Reservoir, Leominster.*

[Number of organisms per cubic centimeter.]

|                                        | 1895.        |           |           |            |            |            |
|----------------------------------------|--------------|-----------|-----------|------------|------------|------------|
|                                        | Jan.         | March.    | May.      | Aug.       | Sept.      | Nov.       |
| Day of examination, . . . . .          | 23           | 21        | 23        | 1          | 26         | 27         |
| Number of sample, . . . . .            | 13697        | 14015     | 14352     | 14735      | 15243      | 15619      |
| <b>PLANTS.</b>                         |              |           |           |            |            |            |
| <b>Diatomaceæ, . . . . .</b>           | <b>9</b>     | <b>3</b>  | <b>20</b> | <b>84</b>  | <b>94</b>  | <b>80</b>  |
| Asterionella, . . . . .                | 4            | 1         | 0         | 27         | 0          | 0          |
| Fragilaria, . . . . .                  | 0            | 0         | 16        | 0          | 0          | 0          |
| Melosira, . . . . .                    | 0            | 0         | 0         | 35         | 5          | 31         |
| Navicula, . . . . .                    | 0            | 0         | 0         | 3          | 1          | 1          |
| Synedra, . . . . .                     | 5            | 0         | 4         | 14         | 88         | 48         |
| Tabellaria, . . . . .                  | 0            | 2         | 0         | 5          | 0          | 0          |
| <b>Cyanophyceæ, . . . . .</b>          | <b>0</b>     | <b>0</b>  | <b>0</b>  | <b>198</b> | <b>73</b>  | <b>8</b>   |
| Anabaena, . . . . .                    | 0            | 0         | 0         | 80         | 0          | 1          |
| Clothrocystis, . . . . .               | 0            | 0         | 0         | 42         | 73         | 7          |
| Celosphaerium, . . . . .               | 0            | 0         | 0         | 76         | 0          | 0          |
| <b>Algæ, . . . . .</b>                 | <b>3,240</b> | <b>10</b> | <b>38</b> | <b>15</b>  | <b>62</b>  | <b>16</b>  |
| Conferva, . . . . .                    | 0            | 0         | 0         | 12         | 0          | 0          |
| Protococcus, . . . . .                 | 0            | 10        | 30        | 0          | 2          | 0          |
| Raphidium, . . . . .                   | 0            | 0         | 0         | 0          | 7          | 0          |
| Scenedesmus, . . . . .                 | 0            | 0         | 0         | 3          | 28         | 16         |
| Selenastrum, . . . . .                 | 0            | 0         | 0         | 0          | 21         | 0          |
| Staurogenia, . . . . .                 | 0            | 0         | 8         | 0          | 4          | 0          |
| Tetraspora, . . . . .                  | 3,240        | 0         | 0         | 0          | 0          | 0          |
| <b>Fungi, Crenothrix, . . . . .</b>    | <b>0</b>     | <b>2</b>  | <b>1</b>  | <b>0</b>   | <b>0</b>   | <b>1</b>   |
| <b>ANIMALS.</b>                        |              |           |           |            |            |            |
| <b>Infusoria, . . . . .</b>            | <b>14</b>    | <b>0</b>  | <b>0</b>  | <b>3</b>   | <b>36</b>  | <b>7</b>   |
| Dinobryon cases, . . . . .             | 4            | 0         | 0         | 0          | 36         | 0          |
| Euglena, . . . . .                     | 5            | 0         | 0         | 0          | 0          | 0          |
| Mallomonas, . . . . .                  | 0            | 0         | 0         | 1          | 0          | 0          |
| Peridinium, . . . . .                  | 5            | 0         | 0         | 2          | 0          | 7          |
| <b>Vermes, . . . . .</b>               | <b>0</b>     | <b>0</b>  | <b>0</b>  | <b>0</b>   | <b>5</b>   | <b>0</b>   |
| Anurea, . . . . .                      | 0            | 0         | 0         | 0          | 2          | 0          |
| Rotatorian ova, . . . . .              | 0            | 0         | 0         | 0          | 3          | 0          |
| <b>Crustacea, Entomostracan ova, .</b> | <b>1</b>     | <b>0</b>  | <b>0</b>  | <b>0</b>   | <b>0</b>   | <b>0</b>   |
| <b>Miscellaneous, Zoöglæa, . . . .</b> | <b>0</b>     | <b>0</b>  | <b>0</b>  | <b>0</b>   | <b>160</b> | <b>4</b>   |
| <b>TOTAL, . . . . .</b>                | <b>3,264</b> | <b>15</b> | <b>59</b> | <b>300</b> | <b>430</b> | <b>116</b> |

## LEOMINSTER.

*Chemical Examination of Water from Haynes Reservoir, Leominster.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                               |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------------------|--------|-------------------------|-------------------|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.                     | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |             |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                               |        |                         |                   |          | Total.      | Dissolved. | Sus-pended. |           |             |           |                  |           |
| 13698   | 1895.<br>Jan. 22    | Distinct.   | Slight.                       | .20    | 2.60                    | 0.95              | .0336    | .0202       | .0152      | .0050       | .19       | .0000       | .0000     | .2449            | 0.5       |
| 14016   | Mar. 20             | Slight.     | Cons.,<br>green.              | .38    | 2.90                    | 1.20              | .0520    | .0228       | .0172      | .0056       | .19       | .0030       | .0002     | .5476            | 0.6       |
| 14353   | May 22              | Decided.    | Heavy,<br>floc. and<br>sandy. | .20    | 2.25                    | 1.40              | .0002    | .0386       | .0172      | .0214       | .18       | .0000       | .0000     | .3876            | 0.3       |
| 14734   | July 30             | Decided.    | Cons.                         | .30    | 3.10                    | 1.95              | .0002    | .0640       | .0276      | .0364       | .20       | .0050       | .0000     | .5390            | 0.3       |
| 15242   | Sept. 24            | Decided.    | Cons.,<br>green               | .35    | 4.45                    | 2.65              | .0038    | .1160       | .0434      | .0726       | .18       | .0060       | .0000     | .6006            | 0.3       |
| 15618   | Nov. 26             | Slight.     | Slight.                       | .33    | 2.75                    | 1.25              | .0000    | .0130       | .0098      | .0032       | .15       | .0000       | .0000     | .4836            | 0.3       |
| Av.     | .....               | .....       | .....                         | .29    | 3.01                    | 1.57              | .0150    | .0458       | .0217      | .0241       | .18       | .0023       | .0000     | .4339            | 0.4       |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | .58 | 3.61 | 2.00 | .0040 | .0647 | -     | -     | .13 | .0084 | -     | -     | -   |
| - | 1888  | - | - | .36 | 2.80 | 1.42 | .0023 | .0352 | -     | -     | .12 | .0075 | .0001 | -     | -   |
| - | 1889  | - | - | .27 | 2.35 | 0.94 | .0010 | .0426 | .0254 | .0172 | .11 | .0034 | .0001 | -     | -   |
| - | 1890  | - | - | .21 | 2.86 | 1.66 | .0003 | .0500 | .0210 | .0290 | .11 | .0063 | .0001 | -     | 0.6 |
| - | 1891  | - | - | .24 | 2.80 | 1.48 | .0005 | .0482 | .0231 | .0251 | .10 | .0097 | .0001 | -     | 0.2 |
| - | 1893  | - | - | .32 | 2.98 | 1.72 | .0050 | .0462 | .0244 | .0218 | .14 | .0028 | .0001 | .5001 | 0.4 |
| - | 1894  | - | - | .28 | 3.02 | 1.79 | .0102 | .0347 | .0214 | .0133 | .15 | .0020 | .0001 | .4628 | 0.3 |
| - | 1895  | - | - | .29 | 3.01 | 1.57 | .0150 | .0458 | .0217 | .0241 | .18 | .0023 | .0000 | .4339 | 0.4 |

\* June to December.

NOTE to analyses of 1895: Odor, in July, none; at other times, vegetable; in May, also disagreeable. In heating, the odor was frequently unpleasant. — The samples were collected from the reservoir.

## LEOMINSTER.

*Microscopical Examination of Water from Haynes Reservoir, Leominster.*

[Number of organisms per cubic centimeter.]

|                                          | 1895.     |            |              |              |               |          |
|------------------------------------------|-----------|------------|--------------|--------------|---------------|----------|
|                                          | Jan.      | March.     | May.         | Aug.         | Sept.         | Nov.     |
| Day of examination, . . . . .            | 23        | 21         | 23           | 1            | 26            | 27       |
| Number of sample, . . . . .              | 13698     | 14016      | 14353        | 14734        | 15242         | 15618    |
| <b>PLANTS.</b>                           |           |            |              |              |               |          |
| <b>Diatomaceæ, . . . . .</b>             | <b>0</b>  | <b>25</b>  | <b>3,150</b> | <b>350</b>   | <b>750</b>    | <b>4</b> |
| Asterionella, . . . . .                  | 0         | 14         | 200          | 0            | 0             | 0        |
| Melosira, . . . . .                      | 0         | 0          | 1,150        | 300          | 750           | 0        |
| Navicula, . . . . .                      | 0         | 0          | 0            | 50           | 0             | 1        |
| Synedra, . . . . .                       | 0         | 7          | 50           | 0            | 0             | 1        |
| Tabellaria, . . . . .                    | 0         | 4          | 1,750        | 0            | 0             | 2        |
| <b>Cyanophyceæ, . . . . .</b>            | <b>2</b>  | <b>0</b>   | <b>150</b>   | <b>2,450</b> | <b>2,800</b>  | <b>0</b> |
| Anabaena, . . . . .                      | 0         | 0          | 0            | 1,300        | 2,300         | 0        |
| Chroococcus, . . . . .                   | 0         | 0          | 0            | 0            | 100           | 0        |
| Cylindrocapsa, . . . . .                 | 1         | 0          | 150          | 1,000        | 200           | 0        |
| Cylindrocapsa, . . . . .                 | 1         | 0          | 0            | 50           | 0             | 0        |
| Microcystis, . . . . .                   | 0         | 0          | 0            | 100          | 0             | 0        |
| <b>Algae, . . . . .</b>                  | <b>24</b> | <b>3</b>   | <b>250</b>   | <b>650</b>   | <b>350</b>    | <b>1</b> |
| Closterium, . . . . .                    | 0         | 0          | 50           | 0            | 0             | 0        |
| Pediastrum, . . . . .                    | 0         | 0          | 50           | 50           | 0             | 0        |
| Protococcus, . . . . .                   | 0         | 0          | 0            | 450          | 0             | 0        |
| Scenedesmus, . . . . .                   | 0         | 3          | 100          | 150          | 250           | 0        |
| Staurastrum, . . . . .                   | 0         | 0          | 50           | 0            | 100           | 1        |
| Tetraspora, . . . . .                    | 24        | 0          | 0            | 0            | 0             | 0        |
| <b>Fungi, Crenothrix, . . . . .</b>      | <b>0</b>  | <b>184</b> | <b>100</b>   | <b>0</b>     | <b>0</b>      | <b>0</b> |
| <b>ANIMALS.</b>                          |           |            |              |              |               |          |
| <b>Infusoria, . . . . .</b>              | <b>31</b> | <b>9</b>   | <b>0</b>     | <b>50</b>    | <b>0</b>      | <b>0</b> |
| Ciliated Infusorian, . . . . .           | 0         | 1          | 0            | 0            | 0             | 0        |
| Dinobryon, . . . . .                     | 3         | 0          | 0            | 0            | 0             | 0        |
| Dinobryon cases, . . . . .               | 6         | 1          | 0            | 0            | 0             | 0        |
| Euglena, . . . . .                       | 2         | 0          | 0            | 0            | 0             | 0        |
| Mallomonas, . . . . .                    | 1         | 0          | 0            | 0            | 0             | 0        |
| Peridinium, . . . . .                    | 19        | 7          | 0            | 50           | 0             | 0        |
| <b>Vermes, Polyarthra, . . . . .</b>     | <b>1</b>  | <b>0</b>   | <b>0</b>     | <b>0</b>     | <b>0</b>      | <b>0</b> |
| <b>Miscellaneous, Zoöglæa, . . . . .</b> | <b>0</b>  | <b>112</b> | <b>300</b>   | <b>0</b>     | <b>0</b>      | <b>2</b> |
| <b>TOTAL, . . . . .</b>                  | <b>58</b> | <b>333</b> | <b>3,950</b> | <b>3,500</b> | <b>10,700</b> | <b>7</b> |

## LEOMINSTER.

*Chemical Examination of Water from Fall Brook, Leominster.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.       | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                 |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 14490   | June 18             | Distinct.   | Cons., yellow.  | .30    | 3.25                    | 1.25              | .0070    | .0210       | .0142      | .0068      | .15       | .0070       | .0001     | .3744            | 0.3       |
| 14491   | June 18             | Distinct.   | Cons., fibrous. | .25    | 3.20                    | 1.15              | .0002    | .0140       | .0102      | .0038      | .13       | .0070       | .0000     | .3237            | 0.2       |
| 14492   | June 18             | V. slight.  | V. slight.      | .25    | 4.75                    | 1.80              | .0004    | .0086       | .0072      | .0014      | .38       | .0900       | .0002     | .2808            | 0.8       |

Odor, faintly vegetable. — The first two samples were collected, respectively, from the South and North branches of Fall Brook where they cross May Street. The last sample was collected from Fall Brook at the falls, a short distance above the first road crossing below May Street.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows : No. 14490, 382; No. 14491, 98; No. 14492, 8.

## WATER SUPPLY OF LEXINGTON.

The works of the Lexington Water Company were purchased by the town Dec. 10, 1895.

*Chemical Examination of Water from the Vine Brook Storage Reservoir of the Lexington Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.   |                     |             |            |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 4391    | May 30              | Slight.     | Cons.      | .23    | 4.75                    | 1.95              | .0012    | .0298       | .0178      | .0120      | .54       | .0500       | .0012     | .4294            | 1.7       |
| 4549    | June 26             | V. slight.  | Slight.    | .30    | 6.05                    | 2.00              | .0012    | .0148       | .0120      | .0028      | .51       | .0470       | .0001     | .4027            | 2.5       |
| 4740    | July 30             | Distinct.   | Cons.      | .30    | 8.50                    | 1.75              | .0002    | .0176       | .0128      | .0048      | .54       | .0420       | .0002     | .4158            | 4.4       |
| 5214    | Sept. 19            | Distinct.   | Slight.    | .40    | 5.80                    | 2.00              | .0022    | .0308       | .0260      | .0048      | .56       | .0030       | .0000     | .5460            | 1.9       |
| 4448    | Oct. 30             | None.       | V. slight. | .80    | 8.95                    | 3.10              | .0024    | .0218       | .0184      | .0034      | .58       | .0630       | .0002     | .9032            | 3.9       |
| 5601    | Nov. 8              | Slight.     | Slight.    | .50    | 6.35                    | 2.15              | .0004    | .0302       | .0248      | .0054      | .51       | .0320       | .0001     | .6045            | 1.9       |
| 652     | Nov. 29             | Slight.     | Slight.    | .42    | 6.80                    | 2.10              | .0006    | .0240       | .0224      | .0016      | .43       | .0300       | .0001     | .6146            | 2.1       |
| 737     | Dec. 23             | V. slight.  | V. slight. | .40    | 6.05                    | 2.30              | .0004    | .0216       | .0200      | .0016      | .43       | .0500       | .0002     | .5683            | 1.9       |
| 15*     | .....               | .....       | .....      | .41    | 6.60                    | 2.17              | .0012    | .0234       | .0187      | .0047      | .52       | .0409       | .0003     | .5536            | 2.6       |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

Odor of the first three samples, vegetable and disagreeable; of the other samples, vegetable or none, some cases becoming mouldy on heating. — No. 15448 was collected from a faucet at the pumping station while pumping; the other samples were collected from the reservoir.

**LEXINGTON.***Microscopical Examination of Water from the Vine Brook Storage Reservoir of the Lexington Water Works.*

[Number of organisms per cubic centimeter.]

|                                  | 1895. |       |       |       |       |       |       |       |
|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                  | June. | June. | Aug.  | Sept. | Nov.  | Nov.  | Dec.  | Dec.  |
| Day of examination, . . . . .    | 1     | 28    | 2     | 21    | 1     | 12    | 2     | 24    |
| Number of sample, . . . . .      | 14391 | 14549 | 14740 | 15214 | 15448 | 15501 | 15632 | 15787 |
| <b>PLANTS.</b>                   |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . . .            | 36    | 308   | 0     | 0     | 0     | 0     | 0     | 0     |
| Synedra, . . . . .               | 28    | 308   | 0     | 0     | 0     | 0     | 0     | 0     |
| Tabellaria, . . . . .            | 8     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Cyanophyceæ, Clathrocystis, . .  | 0     | 0     | 0     | 0     | 0     | 45    | 0     | 0     |
| Algae, . . . . .                 | 19    | 9     | 232   | 1,080 | 0     | 1,012 | 1,041 | 323   |
| Pediastrum, . . . . .            | 0     | 0     | 0     | 0     | 0     | 1,012 | 0     | 0     |
| Protococcus, . . . . .           | 0     | 0     | 232   | 540   | 0     | 0     | 1,032 | 320   |
| Raphidium, . . . . .             | 1     | 6     | 0     | 540   | 0     | 0     | 9     | 3     |
| Staurastrum, . . . . .           | 18    | 3     | 0     | 0     | 0     | 0     | 0     | 0     |
| Fungi, Crenothrix, . . . . .     | 0     | 32    | 24    | 0     | 1     | 0     | 1     | 0     |
| <b>ANIMALS.</b>                  |       |       |       |       |       |       |       |       |
| Infusoria, . . . . .             | 136   | 257   | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon, . . . . .             | 0     | 256   | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, . . . . .       | 136   | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Peridinium, . . . . .            | pr.   | 1     | 0     | 0     | 0     | 0     | 0     | 0     |
| Miscellaneous, Zoögloea, . . . . | 0     | 0     | 0     | 0     | 0     | 80    | 0     | 0     |
| TOTAL, . . . . .                 | 191   | 606   | 256   | 1,080 | 1     | 1,117 | 1,042 | 323   |

**WATER SUPPLY OF LINCOLN.**

(See Concord.)

**WATER SUPPLY OF LONGMEADOW.**

Population in 1895, 620. The works were built by the town, and water was first introduced Feb. 1, 1895. The source of supply is a small brook near the center of the town, from which the water is diverted into a covered collecting well. From this well the water is forced by pumps into an open iron tank 22 feet in diameter and 30 feet high. The brook has a watershed at the point of diversion of about one-half of a square mile, and has a very small population on its watershed.

The collecting well is 30 feet square and 8½ feet deep, built of masonry and covered with a wooden roof. Distributing mains are of cast iron and service pipes of galvanized iron. At the end of the year 1895 there were about 68 connections with the mains.

LOWELL.

## WATER SUPPLY OF LOWELL.

During the year 1895 a second system of tubular wells for supplying water to the city of Lowell was constructed in the valley of River Meadow Brook just above the point where it is crossed by the Old Middlesex Canal in the town of Chelmsford, the wells being distant about a mile up the valley in a straight line from the nearest of the system of tubular wells constructed in 1892.

The new system consists of about 120 2-inch wells, averaging about 45 feet in depth. Two-thirds of the wells are located in two lines 12 feet apart, parallel to the Old Middlesex Canal and about 200 feet south-west of it. The wells are 25 feet apart in the lines. The remaining wells are located in two similar parallel lines about 12 feet apart, extending from the centre of the other lines, and approximately at right angles to them. The wells in these lines are also 25 feet apart, excepting that there is a break of about 300 feet near the middle where there are no wells, the material at that point being found to consist of peaty soil to a depth ranging from 6 to 35 feet. Pumping from this system of wells into the city mains was begun April 5, 1895.

Eighteen wells have been added to the original system of wells lower down the valley.

During the year 1895 about 66 per cent. of the water supplied to the city was drawn from the systems of tubular wells in the valley of River Meadow Brook, the remainder being drawn from the Merrimack River.

The results of analyses of samples of water from the Merrimack River and from the two systems of tubular wells in the valley of River Meadow Brook are given in the following tables.

These results show that the water of the original system of tubular wells in the valley of River Meadow Brook just above Plain Street has been somewhat harder than last year and has contained a considerably greater amount of residue on evaporation.

Analyses of samples from the new system of tubular wells in the valley of River Meadow Brook have been made once in two weeks and sometimes more frequently since pumping from these wells into the city mains was begun in April. The results of these investigations show that there has been a very great increase in the color, residue on evaporation, ammonia, hardness and iron during the year, a maximum being reached in November. The iron oxidizes on



**LOWELL.**

exposure to the air, giving the water at first a milky turbidity, and subsequently precipitating in the form of a rusty sediment.

*Chemical Examination of Water from the Merrimack River above Lowell, opposite the Intake of the Lowell Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|------------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.       | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                  |                |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13660   | 1895.<br>Jan. 15    | Slight, milky.   | Slight.        | .30    | 4.25                    | 1.25              | .0076    | .0174       | .0148      | .0026      | .29       | .0040       | .0000     | .4345            | 1.6       |
| 13843   | Feb. 19             | Distinct.        | Slight.        | .28    | 4.35                    | 1.35              | .0084    | .0158       | .0140      | .0018      | .25       | .0050       | .0000     | .4329            | 1.4       |
| 13999   | Mar. 19             | Slight.          | Cons., brown.  | .48    | 3.40                    | 1.15              | .0026    | .0166       | .0134      | .0032      | .17       | .0070       | .0001     | .5925            | 0.8       |
| 14153   | Apr. 16             | Decided, clayey. | Cons., earthy. | .53    | 3.40                    | 1.35              | .0068    | .0296       | .0134      | .0162      | .13       | .0100       | .0001     | .6636            | 1.5       |
| 14335   | May 21              | Slight.          | Cons.          | .38    | 3.25                    | 1.35              | .0014    | .0128       | .0088      | .0040      | .17       | .0080       | .0001     | .5016            | 1.3       |
| 14481   | June 18             | Distinct.        | Slight.        | .27    | 3.65                    | 1.55              | .0008    | .0196       | .0124      | .0072      | .20       | .0050       | .0002     | .3538            | 0.8       |
| 14570   | Aug. 20             | Distinct.        | Slight.        | .38    | 4.45                    | 2.10              | .0028    | .0150       | .0118      | .0032      | .22       | .0050       | .0001     | .3588            | 0.9       |
| 15183   | Sept. 17            | Slight.          | Slight.        | .22    | 3.55                    | 1.05              | .0056    | .0170       | .0154      | .0016      | .26       | .0030       | .0001     | .3471            | 1.6       |
| 15369   | Oct. 15             | Distinct.        | Cons.          | .60    | 4.55                    | 1.80              | .0000    | .0258       | .0198      | .0060      | .31       | .0070       | .0001     | .8034            | 1.6       |
| 15570   | Nov. 20             | Slight.          | Slight.        | .72    | 3.65                    | 1.55              | .0004    | .0212       | .0162      | .0050      | .19       | .0070       | .0000     | .8408            | 1.1       |
| 15752   | Dec. 17             | Slight.          | Slight.        | .40    | 3.75                    | 1.60              | .0060    | .0156       | .0144      | .0012      | .14       | .0120       | .0001     | .5298            | 1.1       |
| Av.     | .....               | .....            | .....          | .41    | 3.84                    | 1.46              | .0039    | .0187       | .0140      | .0047      | .21       | .0066       | .0001     | .5353            | 1.2       |

*Averages by Years.*

|   |       |   |   |     |       |       |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|-------|-------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | .44 | 4.29  | 1.16  | .0021 | .0168 | -     | -     | .17 | .0084 | -     | -     | -   |
| - | 1888  | - | - | .30 | 3.42  | 0.97  | .0016 | .0160 | .0133 | .0027 | .16 | .0099 | .0002 | -     | -   |
| - | 1889  | - | - | .28 | 2.05† | 0.84† | .0018 | .0149 | .0126 | .0023 | .14 | .0071 | .0002 | -     | -   |
| - | 1890  | - | - | .30 | 3.57‡ | 1.54‡ | .0014 | .0128 | .0104 | .0024 | .13 | .0111 | .0001 | -     | 1.4 |
| - | 1891  | - | - | .29 | 3.43  | 1.23  | .0017 | .0129 | .0109 | .0029 | .13 | .0137 | .0001 | -     | 1.2 |
| - | 1892  | - | - | .39 | 3.61  | 1.36  | .0021 | .0141 | .0113 | .0028 | .14 | .0092 | .0001 | -     | 1.3 |
| - | 1893  | - | - | .33 | 3.39  | 1.18  | .0028 | .0149 | .0120 | .0029 | .17 | .0083 | .0001 | .4437 | 1.1 |
| - | 1894  | - | - | .35 | 3.55  | 1.26  | .0034 | .0135 | .0109 | .0026 | .18 | .0063 | .0001 | .3990 | 1.1 |
| - | 1895  | - | - | .41 | 3.84  | 1.46  | .0039 | .0187 | .0140 | .0047 | .21 | .0066 | .0001 | .5353 | 1.3 |

\* June to December.

† January to May.

‡ September to December.

NOTE to analyses of 1895: Odor, generally vegetable and musty or mouldy, sometimes unpleasant or disagreeable. — The samples were collected from the river, about 1 foot beneath the surface.

For a comparison of the analyses of the river at Lowell and Lawrence for a series of years, see "Merrimack River" in the chapter on "Examination of Rivers" in a subsequent portion of this report.

LOWELL.

*Chemical Examination of Water from Tubular Wells in the Valley of River Meadow Brook, a Short Distance above Plain Street.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |               |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed | Hardness. | Iron. |
|---------|---------------------|-------------|---------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|-----------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.     | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                 |           |       |
|         | 1895.               |             |               |        |                         |          |             |           |             |           |                 |           |       |
| 13661   | Jan. 15             | V. slight.  | V. slight.    | .04    | 8.90                    | .0000    | .0034       | .58       | .0280       | .0001     | .0276           | 3.9       | .0125 |
| 13844   | Feb. 19             | None.       | None.         | .03    | 8.80                    | .0002    | .0022       | .60       | .0320       | .0001     | .0328           | 3.8       | .0115 |
| 14000   | Mar. 19             | V. slight.  | Slight, dark. | .02    | 9.00                    | .0002    | .0018       | .60       | .0370       | .0001     | .0434           | 4.2       | .0300 |
| 14154   | Apr. 16             | V. slight.  | None.         | .02    | 8.50                    | .0000    | .0014       | .50       | .0200       | .0000     | .0671           | 3.4       | .0120 |
| 14337   | May 21              | None.       | None.         | .04    | 8.90                    | .0002    | .0006       | .54       | .0330       | .0000     | .0434           | 3.8       | .0140 |
| 14482   | June 18             | None.       | None.         | .02    | 8.20                    | .0000    | .0028       | .47       | .0150       | .0000     | .0328           | 3.5       | .0100 |
| 14656   | July 22             | None.       | None.         | .03    | 9.90                    | .0000    | .0030       | .49       | .0250       | .0001     | .0600           | 3.8       | .0120 |
| 14872   | Aug. 20             | None.       | None.         | .02    | 9.40                    | .0000    | .0032       | .52       | .0220       | .0001     | .0468           | 3.6       | .0120 |
| 15185   | Sept. 17            | None.       | None.         | .02    | 10.00                   | .0002    | .0014       | .59       | .0280       | .0001     | .0546           | 3.8       | .0090 |
| 15372   | Oct. 15             | None.       | V. slight.    | .01    | 10.20                   | .0000    | .0014       | .72       | .0500       | .0002     | .0507           | 4.2       | .0040 |
| 15591   | Nov. 21             | None.       | None.         | .01    | 9.50                    | .0000    | .0036       | .56       | .0450       | .0011     | .0858           | 3.9       | .0100 |
| 15753   | Dec. 17             | None.       | V. slight.    | .02    | 9.40                    | .0000    | .0042       | .51       | .0530       | .0002     | .0962           | 3.6       | .0060 |
| Av..    | 1895                | .....       | .....         | .02    | 9.22                    | .0001    | .0024       | .55       | .0323       | .0002     | .0534           | 3.8       | .0119 |
| Av..    | 1894                | .....       | .....         | .02    | 7.33                    | .0003    | .0014       | .55       | .0549       | .0002     | .0232           | 2.8       | .0078 |

**NOTE** to analyses of 1895: Odor, in September, November and December, distinct; at other times, none. — The samples were collected from a faucet at the pumping station while pumping. The wells are locally known as the "Cook" wells.

*Microscopical Examination.*

The average number of organisms per cubic centimeter found in these samples was 31, consisting chiefly of *Crenothrix*.

**LOWELL.**

*Chemical Examination of Water from Tubular Wells in the Valley of River Meadow Brook, a Short Distance above the Old Middlesex Canal in Chelmsford.*

[Parts per 100,000.]

| Number. | Date of Collection.     | APPEARANCE.      |                |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|-------------------------|------------------|----------------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                         | Turbidity.       | Sediment.      | Color. |                         | Free.    | Albu- minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 18718   | <b>1895.</b><br>Jan. 24 | None.            | None.          | .00    | 4.40                    | .0000    | .0000         | .18       | .0130       | .0000     | .0000            | 1.6       | .0000 |
| 13905   | Mar. 4                  | Distinct, flocc. | Slight, white. | .25    | 6.60                    | .0000    | .0002         | .31       | .0000       | .0000     | .0308            | 2.6       | .0920 |
| 14028   | Mar. 20                 | Slight.          | Slight.        | .25    | 6.80                    | .0006    | .0004         | .29       | .0000       | .0000     | .0632            | 2.5       | .0740 |
| 14095   | Apr. 3                  | None.            | None.          | .00    | 5.90                    | .0004    | .0000         | .27       | .0090       | .0000     | .0192            | 2.3       | .0070 |
| 14101   | Apr. 6                  | None.            | None.          | .03    | 6.00                    | .0010    | .0020         | .31       | .0050       | .0001     | .0370            | 2.3       | .0200 |
| 14138   | Apr. 12                 | V. slight.       | None.          | .04    | 6.30                    | .0004    | .0008         | .31       | .0000       | .0000     | .0231            | 2.3       | .0300 |
| 14209   | Apr. 24                 | None.            | V. slight.     | .07    | 5.80                    | .0010    | .0018         | .30       | .0060       | .0000     | .0355            | 2.2       | .0330 |
| 14217   | Apr. 30                 | Slight.          | Slight.        | .08    | 6.50                    | .0012    | .0014         | .32       | .0080       | .0000     | .0231            | 2.6       | .0020 |
| 14252   | May 7                   | V. slight.       | V. slight.     | .02    | 6.50                    | .0006    | .0006         | .28       | .0030       | .0000     | .0131            | 2.7       | .0400 |
| 14294   | May 14                  | Distinct.        | V. slight.     | .10    | 7.50                    | .0018    | .0008         | .28       | .0060       | .0000     | .0158            | 2.6       | .0600 |
| 14336   | May 21                  | Slight.          | Slight.        | .10    | 6.60                    | .0006    | .0004         | .32       | .0070       | .0000     | .0237            | 2.7       | .0580 |
| 14379   | May 28                  | Slight.          | Slight.        | .12    | 7.70                    | .0006    | .0010         | .30       | .0050       | .0000     | .0494            | 2.7       | .0300 |
| 14427   | June 5                  | V. slight.       | V. slight.     | .12    | 7.50                    | .0018    | .0036         | .33       | .0050       | .0000     | .0304            | 2.6       | .0660 |
| 14483   | June 18                 | V. slight.       | V. slight.     | .20    | 7.60                    | .0014    | .0012         | .30       | .0070       | .0000     | .0218            | 2.9       | .0690 |
| 14601   | July 10                 | None.            | V. slight.     | .04    | 7.40                    | .0012    | .0012         | .33       | .0070       | .0000     | .0553            | 3.0       | .0370 |
| 14657   | July 22                 | Slight.          | Slight.        | .13    | 7.80                    | .0008    | .0016         | .33       | .0070       | .0001     | .0600            | 3.5       | .0350 |
| 14786   | Aug. 7                  | None.            | Slight.        | .10    | 7.30                    | .0020    | .0010         | .33       | .0100       | .0000     | .0312            | 3.5       | .0420 |
| 14871   | Aug. 20                 | V. slight.       | V. slight.     | .07    | 7.00                    | .0014    | .0012         | .35       | .0060       | .0001     | .0624            | 2.9       | .0430 |
| 14965   | Sept. 4                 | None.            | None.          | .10    | 7.50                    | .0080    | .0010         | .36       | .0000       | .0000     | .0462            | 2.7       | .0360 |
| 15184   | Sept. 17                | None.            | None.          | .10    | 7.20                    | .0010    | .0016         | .34       | .0070       | .0000     | .0374            | 2.7       | .0310 |
| 15303   | Oct. 2                  | None.            | None.          | .08    | 7.20                    | .0010    | .0020         | .35       | .0070       | .0000     | .0702            | 2.6       | .0290 |
| 15373   | Oct. 15                 | V. slight.       | V. slight.     | .03    | 11.00                   | .0026    | .0020         | .35       | .0180       | .0001     | .0842            | 4.6       | .0470 |
| 15479   | Nov. 5                  | None.            | V. slight.     | .40    | 20.50                   | .0060    | .0030         | .33       | .0220       | .0003     | .0975            | 8.7       | .2000 |
| 15559   | Nov. 18                 | Distinct.        | Slight, rusty. | .40    | 25.10                   | .0080    | .0042         | .35       | .0120       | .0000     | .1638            | 10.3      | .3400 |
| 15571   | Nov. 19                 | Slight, milky.   | Slight.        | .20    | 23.90                   | .0064    | .0060         | .29       | .0150       | .0001     | .1654            | 10.6      | .2250 |
| 15668   | Dec. 3                  | None.            | V. slight.     | .18    | 20.10                   | .0040    | .0054         | .33       | .0100       | .0001     | .1326            | 9.7       | .0750 |
| 15754   | Dec. 17                 | V. slight.       | V. slight.     | .12    | 20.10                   | .0054    | .0046         | .31       | .0130       | .0000     | .0731            | 9.7       | .0690 |

Odor of the last four samples, vegetable; of the other samples, none. — The samples were collected from a faucet at the pumping station while pumping. The wells are locally known as the "Hydraulic Company's" wells.

*Microscopical Examination.*

The average number of organisms per cubic centimeter found in these samples was 28, consisting chiefly of *Crenothrix*.

LUDLOW.

## WATER SUPPLY OF LUDLOW.

(See *Springfield*.)

## WATER SUPPLY OF LYNN AND SAUGUS.

*Chemical Examination of Water from Breed's Pond, Lynn.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |          | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrate.       | Nitrite. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |          |                  |           |
| 13629   | 1893.<br>Jan. 8     | V. slight.  | Slight.    | .02    | 3.90                            | 1.25                 | .0030    | .0176       | .0162      | .0014           | .65       | .0040          | .0000    | .4797            | 0.9       |
| 13807   | Feb. 12             | V. slight.  | V. slight. | .50    | 4.00                            | 1.10                 | .0016    | .0152       | .0122      | .0030           | .78       | .0050          | .0000    | .5000            | 1.3       |
| 13969   | Mar. 12             | Slight.     | Cons.      | .25    | 3.15                            | 1.25                 | .0008    | .0166       | .0094      | .0072           | .54       | .0050          | .0001    | .3580            | 0.6       |
| 14117   | Apr. 9              | Slight.     | Cons.      | .53    | 3.70                            | 1.55                 | .0010    | .0124       | .0102      | .0022           | .56       | .0050          | .0000    | .5197            | 0.9       |
| 14283   | May 13              | Slight.     | Slight.    | .52    | 3.80                            | 1.30                 | .0002    | .0216       | .0172      | .0044           | .52       | .0020          | .0000    | .6372            | 1.1       |
| 14455   | June 11             | Slight.     | Cons.      | .40    | 3.80                            | 2.10                 | .0010    | .0174       | .0158      | .0016           | .52       | .0050          | .0001    | .4820            | 0.8       |
| 14633   | July 16             | Slight.     | Cons.      | .50    | 3.25                            | 1.55                 | .0000    | .0214       | .0188      | .0026           | .58       | .0070          | .0001    | .4914            | 0.7       |
| 14828   | Aug. 12             | Distinct.   | Cons.      | .33    | 3.70                            | 1.40                 | .0012    | .0212       | .0188      | .0024           | .59       | .0030          | .0001    | .5148            | 0.9       |
| 15130   | Sept. 9             | Distinct.   | Slight.    | .33    | 4.10                            | 1.50                 | .0000    | .0220       | .0198      | .0022           | .61       | .0000          | .0001    | .4914            | 0.9       |
| 15339   | Oct. 9              | V. slight.  | Slight.    | .37    | 3.55                            | 1.30                 | .0004    | .0256       | .0226      | .0030           | .66       | .0000          | .0000    | .4290            | 0.9       |
| 15525   | Nov. 12             | V. slight.  | V. slight. | .57    | 4.00                            | 1.85                 | .0044    | .0292       | .0270      | .0022           | .52       | .0050          | .0000    | .5788            | 1.3       |
| 15710   | Dec. 9              | V. slight.  | Slight.    | .90    | 4.00                            | 1.65                 | .0054    | .0186       | .0172      | .0014           | .46       | .0020          | .0001    | .6568            | 0.8       |
| Av.     | .....               | .....       | .....      | .48    | 3.75                            | 1.48                 | .0016    | .0199       | .0171      | .0028           | .58       | .0036          | .0001    | .5032            | 0.9       |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | .51 | 3.70 | 1.32 | .0006 | .0217 | -     | -     | .44 | .0024 | -     | -     | -   |
| - | 1888  | - | - | .48 | 3.71 | 1.42 | .0029 | .0227 | -     | -     | .45 | .0053 | .0001 | -     | -   |
| - | 1889  | - | - | .45 | 3.09 | 1.02 | .0007 | .0208 | .0165 | .0043 | .41 | .0035 | .0001 | -     | -   |
| - | 1890  | - | - | .42 | 3.62 | 1.51 | .0014 | .0196 | .0155 | .0041 | .41 | .0052 | .0001 | -     | 1.1 |
| - | 1891  | - | - | .35 | 3.85 | 1.37 | .0009 | .0156 | .0131 | .0025 | .40 | .0080 | .0001 | -     | 0.8 |
| - | 1892  | - | - | .43 | 3.65 | 1.38 | .0004 | .0220 | .0177 | .0043 | .49 | .0055 | .0000 | -     | 1.0 |
| - | 1893  | - | - | .65 | 3.61 | 1.41 | .0039 | .0214 | .0181 | .0033 | .55 | .0054 | .0001 | .5102 | 1.1 |
| - | 1894  | - | - | .65 | 3.77 | 1.47 | .0023 | .0225 | .0191 | .0034 | .58 | .0032 | .0000 | .5264 | 0.9 |
| - | 1895  | - | - | .48 | 3.75 | 1.48 | .0016 | .0199 | .0171 | .0028 | .58 | .0036 | .0001 | .5032 | 0.9 |

\* June to December.

**NOTE** to analyses of 1895: Odor, generally vegetable, becoming stronger and sometimes unpleasant on heating. — The samples were collected from the pond near the gate-house, about 1 foot beneath the surface.

## LYNN AND SAUGUS.

*Microscopical Examination of Water from Breed's Pond, Lynn.*

[Number of organisms per cubic centimeter.]

|                                    | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                    | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .          | 9     | 14    | 14    | 10    | 14    | 12    | 17    | 14    | 12    | 10    | 13    | 12    |
| Number of sample, . . .            | 13629 | 15807 | 13909 | 14117 | 14283 | 14455 | 14633 | 14828 | 15130 | 15339 | 15525 | 15710 |
| <b>PLANTS.</b>                     |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>Diatomaceæ,</b> . . . .         | 0     | 0     | 0     | 9     | 77    | 290   | 508   | 614   | 336   | 22    | 33    | 3     |
| Asterionella, . . . .              | 0     | 0     | 0     | 0     | 24    | 55    | 184   | 192   | 288   | 18    | 32    | 1     |
| Melosira, . . . .                  | 0     | 0     | 0     | 0     | 0     | 1     | 7     | 0     | 0     | 0     | 0     | 0     |
| Synedra, . . . .                   | 0     | 0     | 0     | 1     | 10    | 2     | 1     | 2     | 0     | 0     | 1     | 2     |
| Tabellaria, . . . .                | 0     | 0     | 0     | 8     | 43    | 232   | 316   | 420   | 48    | 9     | 0     | 0     |
| <b>Cyanophyceæ,</b> . . . .        | 0     | 0     | 0     | 0     | 32    | 0     | 4     | 0     | 0     | 0     | 10    | 0     |
| Anabaena, . . . .                  | 0     | 0     | 0     | 0     | 32    | 0     | 4     | 0     | 0     | 0     | 0     | 0     |
| Nostoc, . . . .                    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 10    | 0     |
| <b>Algae,</b> . . . .              | 0     | 0     | 0     | 1     | 15    | 22    | 303   | 0     | 16    | 26    | 0     | 4     |
| Conferva, . . . .                  | 0     | 0     | 0     | 0     | 0     | 0     | 6     | 0     | 0     | 0     | 0     | 0     |
| Pediastrum, . . . .                | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 10    | 0     | 0     |
| Protocecus, . . . .                | 0     | 0     | 0     | 1     | 6     | 18    | 272   | 0     | 0     | 0     | 0     | 0     |
| Raphidium, . . . .                 | 0     | 0     | 0     | 0     | 9     | 4     | 25    | 0     | 8     | 0     | 0     | 0     |
| Staurogenia, . . . .               | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 8     | 16    | 0     | 4     |
| <b>ANIMALS.</b>                    |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>Rhizopoda, Actinophrys,</b> . . | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 2     |
| <b>Infusoria,</b> . . . .          | 5     | 12    | 1     | 6     | 126   | 0     | 371   | 493   | 45    | 8     | 24    | 2     |
| Ciliated Infusorian, . . . .       | 0     | 0     | 0     | 0     | 0     | 0     | 120   | 0     | 0     | 1     | 0     | 0     |
| Dinobryon, . . . .                 | 0     | 0     | 0     | 0     | 0     | 0     | 244   | 448   | 40    | 0     | 22    | 0     |
| Dinobryon cases, . . . .           | 0     | 6     | 0     | 3     | 120   | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Mallomonas, . . . .                | 1     | 0     | 1     | 0     | 5     | 0     | 1     | 0     | 0     | 4     | 0     | 2     |
| Peridinium, . . . .                | 4     | 4     | 0     | 3     | 1     | 0     | 4     | 44    | 2     | 1     | 1     | 0     |
| Trachelomonas, . . . .             | pr.   | 2     | 0     | 0     | 0     | 0     | 2     | 1     | 3     | 2     | 1     | 0     |
| <b>Vermes,</b> . . . .             | 0     | 0     | 0     | 0     | 6     | 0     | 0     | 1     | 0     | 0     | 0     | 0     |
| Anurea, . . . .                    | 0     | 0     | 0     | 0     | 4     | 0     | 0     | 1     | 0     | 0     | 0     | 0     |
| Rotifer, . . . .                   | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| <b>Miscellaneous,</b> . . . .      | 0     | 0     | 0     | 56    | 0     | 0     | 0     | .06   | 48    | 24    | 0     | 0     |
| Acarina, . . . .                   | 0     | 0     | 0     | 0     | 0     | 0     | 0     | .06   | .06   | 0     | 0     | 0     |
| Zoëglia, . . . .                   | 0     | 0     | 0     | 56    | 0     | 0     | 0     | 0     | 48    | 24    | 0     | 0     |
| <b>TOTAL,</b> . . . .              | 5     | 12    | 1     | 72    | 257   | 312   | 1,186 | 1,108 | 445   | 80    | 67    | 11    |

LYNN AND SAUGU  
Chemical Examination of Water from Birch Pond, Lynn.

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |                  |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |            |            |                 | Chlorine. | NITROGEN<br>AS |            | Oxygen Consumed. | Hardness. |
|---------------------|-------------|------------------|--------|---------------------------------|----------------------|----------|------------|------------|-----------------|-----------|----------------|------------|------------------|-----------|
|                     | Turbidity.  | Sediment.        | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid |            |                 |           | Nitratea.      | Nitritica. |                  |           |
|                     |             |                  |        |                                 |                      |          | Total.     | Dissolved. | Sus-<br>pended. |           |                |            |                  |           |
| 1895.               |             |                  |        |                                 |                      |          |            |            |                 |           |                |            |                  |           |
| Jan. 8              | Decided.    | Slight.          | .90    | 7.00                            | 3.30                 | .0018    | .0426      | .0264      | .0162           | .86       | .0100          | .0002      | .7621            | 1.9       |
| Feb. 12             | V. slight.  | Slight.          | .60    | 5.65                            | 2.05                 | .0086    | .0376      | .0228      | .0148           | .78       | .0100          | .0000      | .7216            | 1.8       |
| Apr. 1              | Distinct.   | Slight.          | .55    | 5.85                            | 1.65                 | .0086    | .0296      | .0222      | .0074           | .69       | .0090          | .0000      | .6828            | 1.6       |
| Apr. 9              | V. slight.  | Slight.          | .55    | 5.15                            | 1.75                 | .0038    | .0228      | .0158      | .0070           | .71       | .0080          | .0001      | .6083            | 1.7       |
| May 13              | Slight.     | Cons.            | .47    | 4.75                            | 1.60                 | .0004    | .0266      | .0210      | .0056           | .66       | .0030          | .0000      | .6336            | 1.7       |
| June 11             | Slight.     | Cons.,<br>brown. | .32    | 4.25                            | 1.75                 | .0006    | .0220      | .0172      | .0048           | .66       | .0000          | .0001      | .4742            | 1.1       |
| July 16             | Slight.     | Cons.            | .50    | 4.65                            | 2.30                 | .0004    | .0264      | .0186      | .0078           | .66       | .0030          | .0000      | .6708            | 1.3       |
| Aug 12              | Distinct.   | Cons.,<br>brown. | .35    | 4.40                            | 1.95                 | .0020    | .0294      | .0230      | .0064           | .68       | .0050          | .0001      | .5304            | 1.3       |
| Sept. 9             | Distinct.   | Slight.          | .48    | 4.60                            | 1.95                 | .0046    | .0256      | .0226      | .0030           | .71       | .0000          | .0001      | .5538            | 1.4       |
| Oct. 9              | V. slight.  | Slight.          | .68    | 4.15                            | 1.95                 | .0040    | .0364      | .0308      | .0056           | .75       | .0030          | .0000      | .5538            | 0.9       |
| Nov. 12             | Distinct.   | Slight.          | .90    | 5.80                            | 2.35                 | .0026    | .0330      | .0268      | .0062           | .67       | .0170          | .0001      | .5132            | 1.4       |
| Dec. 9              | V. slight.  | Slight.          | .90    | 4.80                            | 2.45                 | .0030    | .0178      | .0162      | .0016           | .52       | .0100          | .0001      | .8073            | 1.3       |
| .....               | .....       | .....            | .60    | 5.05                            | 2.12                 | .0031    | .0294      | .0222      | .0072           | .70       | .0063          | .0001      | .6174            | 1.4       |

Averages by Years.

|      |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| 187* | - | - | .57 | 4.02 | 1.61 | .0016 | .0289 | -     | -     | .43 | .0044 | -     | -     | -   |
| 88   | - | - | .33 | 3.48 | 1.40 | .0026 | .0287 | -     | -     | .45 | .0082 | .0001 | -     | -   |
| 9    | - | - | .23 | 2.96 | 1.14 | .0014 | .0236 | .0190 | .0046 | .41 | .0048 | .0001 | -     | -   |
| 7    | - | - | .86 | 3.57 | 1.35 | .0013 | .0227 | .0179 | .0048 | .42 | .0088 | .0001 | -     | 1.0 |
|      | - | - | .42 | 3.26 | 1.30 | .0005 | .0241 | .0183 | .0058 | .40 | .0065 | .0001 | -     | 0.7 |
|      | - | - | .48 | 3.73 | 1.56 | .0016 | .0299 | .0227 | .0072 | .47 | .0092 | .0001 | -     | 1.0 |
|      | - | - | .76 | 4.21 | 1.63 | .0052 | .0299 | .0218 | .0081 | .51 | .0059 | .0001 | .5285 | 1.0 |
|      | - | - | .75 | 4.47 | 1.88 | .0053 | .0292 | .0242 | .0050 | .57 | .0076 | .0001 | .6299 | 1.1 |
|      | - | - | .60 | 5.05 | 2.12 | .0031 | .0294 | .0222 | .0072 | .70 | .0063 | .0001 | .6174 | 1.4 |

\* June to December.

analysis of 1895: Odor, generally vegetable, sometimes also unpleasant, rarely none. — re collected from the pond near the gate-house, 1 foot beneath the surface. A portion bring this pond during the year was pumped from the Saugus River. the quality of the water of this river see reports for 1894 and 1893.

## LYNN AND SAUGUS.

*Microscopical Examination of Water from Birch Pond, Lynn.*

[Number of organisms per cubic centimeter.]

|                                 | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|---------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                 | Jan.  | Feb.  | Apr.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .       | 9     | 14    | 3     | 10    | 14    | 12    | 17    | 14    | 12    | 10    | 13    | 12    |
| Number of sample, . . .         | 13628 | 13806 | 14078 | 14116 | 14282 | 14454 | 14632 | 14827 | 15131 | 15338 | 15524 | 15709 |
| PLANTS.                         |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . .             | 4     | 0     | 3     | 0     | 664   | 59    | 1,449 | 1,886 | 466   | 239   | 7     | 21    |
| Asterionella, . . . .           | 0     | 0     | 0     | 0     | 644   | 0     | 480   | 196   | 420   | 11    | 0     | 0     |
| Cyclotella, . . . .             | 1     | 0     | 0     | 0     | 1     | 23    | 920   | 252   | 0     | 0     | 0     | 2     |
| Fragilaria, . . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 50    | 0     | 0     | 0     | 0     |
| Melosira, . . . .               | 0     | 0     | 0     | 0     | 0     | 0     | 6     | 8     | 12    | 80    | 0     | 0     |
| Synedra, . . . .                | 3     | 0     | 3     | 0     | 7     | 25    | 3     | 0     | 8     | 88    | 7     | 13    |
| Tabellaria, . . . .             | 0     | 0     | 0     | 0     | 12    | 5     | 40    | 1,400 | 26    | 60    | 0     | 4     |
| Cyanophyceæ, . . . .            | 0     | 0     | 0     | 0     | 0     | 67    | 0     | 17    | 1     | 0     | 0     | 0     |
| Anabaena, . . . .               | 0     | 0     | 0     | 0     | 0     | 67    | 0     | 0     | 0     | 0     | 0     | 0     |
| Microcystis, . . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 17    | 1     | 0     | 0     | 0     |
| Algæ, . . . .                   | 9     | 0     | 10    | 3     | 389   | 466   | 39    | 83    | 27    | 48    | 1     | 11    |
| Arthrodesmus, . . . .           | 0     | 0     | 0     | 0     | 0     | 1     | 10    | 0     | 2     | 0     | 0     | 0     |
| Chlorococcus, . . . .           | 0     | 0     | 0     | 0     | 20    | 8     | 0     | 0     | 0     | 3     | 0     | 0     |
| Protooccus, . . . .             | 4     | 0     | 4     | 0     | 352   | 452   | 11    | 51    | 0     | 1     | 0     | 4     |
| Raphidium, . . . .              | 0     | 0     | 0     | 0     | 16    | 0     | 0     | 6     | 12    | 19    | 0     | 5     |
| Scenedesmus, . . . .            | 0     | 0     | 0     | 0     | 0     | 5     | 0     | 2     | 0     | 1     | 0     | 2     |
| Selenastrum, . . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 20    | 0     | 0     |
| Staurostrum, . . . .            | 0     | 0     | 0     | 0     | 1     | 20    | 18    | 20    | 13    | 1     | 0     | 0     |
| Staurigenia, . . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 0     | 3     | 0     | 0     |
| Zooporens, . . . .              | 5     | 0     | 6     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     |
| Fungi, Crenothrix, . . . .      | 0     | 0     | 7     | 1     | 0     | 33    | 0     | 0     | 1     | 1     | 0     | 1     |
| ANIMALS.                        |       |       |       |       |       |       |       |       |       |       |       |       |
| Rhizopoda, Actinophrys, . . . . | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Infusoria, . . . .              | 66    | 277   | 152   | 163   | 42    | 6     | 171   | 130   | 39    | 10    | 20    | 6     |
| Dinobryon, . . . .              | 0     | 0     | 31    | 80    | 1     | 0     | 0     | 0     | 0     | 4     | 0     | 3     |
| Dinobryon caesi, . . . .        | 4     | 44    | 100   | 68    | 36    | 0     | 116   | 22    | 5     | 0     | 0     | 0     |
| Euglena, . . . .                | 2     | 124   | 1     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Mallomonas, . . . .             | 0     | 0     | 1     | 3     | 1     | 0     | 0     | 8     | 0     | 0     | 0     | 0     |
| Peridinium, . . . .             | 54    | 108   | 19    | 9     | 4     | 6     | 3     | 0     | 0     | 3     | 20    | 3     |
| Synura, . . . .                 | 6     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Tintinnidium, . . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     |
| Trachelomonas, . . . .          | 0     | 1     | 0     | 1     | 0     | 0     | 50    | 100   | 32    | 3     | 0     | 0     |
| Vorticella, . . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     |
| Vermes, . . . .                 | 0     | 0     | 0     | 0     | 4     | 0     | 0     | 0     | 1     | 2     | 0     | 0     |
| Aurea, . . . .                  | 0     | 0     | 0     | 0     | 4     | 0     | 0     | 0     | 0     | 1     | 0     | 0     |
| Rotatorian ova, . . . .         | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 1     | 0     | 0     |
| Crustacea, Daphnia, . . . .     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | .08   | 0     | 0     |
| Miscellaneous, . . . .          | 0     | 0     | 0     | 0     | 54    | 0     | .20   | .06   | 112   | 0     | 80    | 5     |
| Acarina, . . . .                | 0     | 0     | 0     | 0     | 0     | 0     | .20   | .06   | .04   | 0     | 0     | 0     |
| Zoöglana, . . . .               | 0     | 0     | 0     | 0     | 54    | 0     | 0     | 0     | 112   | 0     | 80    | 5     |
| TOTAL, . . . .                  | 79    | 277   | 174   | 167   | 1,153 | 651   | 1,659 | 2,116 | 647   | 300   | 108   | 44    |

LYNN AND SAUGUS.

*Chemical Examination of Water from Walden Pond, Lynn.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                 |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.       | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |                 |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 14285   | 1895.<br>May 13     | V. slight.  | Cons.           | 0.73   | 3.90                            | 1.70                 | .0044    | .0264       | .0242      | .0022           | .46       | .0030          | .0000     | .7886            | 1.1       |
| 14457   | June 11             | Slight.     | Cons.<br>brown. | 0.70   | 3.65                            | 2.10                 | .0002    | .0304       | .0224      | .0080           | .56       | .0030          | .0001     | .6318            | 0.6       |
| 14635   | July 16             | Slight.     | Cons.           | 1.30   | 4.40                            | 2.25                 | .0328    | .0536       | .0320      | .0216           | .50       | .0070          | .0003     | .8580            | 0.5       |
| Av.     | .....               | .....       | .....           | 0.91   | 3.98                            | 2.02                 | .0125    | .0368       | .0262      | .0106           | .51       | .0043          | .0001     | .7425            | 0.7       |

*Averages by Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1890  | - | - | 1.06 | 4.98 | 2.53 | .0292 | .0432 | .0351 | .0081 | .34 | .0057 | .0001 | -     | 1.1 |
| - | 1891  | - | - | 1.21 | 4.32 | 2.20 | .0058 | .0615 | .0408 | .0212 | .34 | .0091 | .0001 | -     | 0.7 |
| - | 1892  | - | - | 0.90 | 4.81 | 2.50 | .0094 | .0626 | .0383 | .0245 | .41 | .0116 | .0001 | -     | 0.6 |
| - | 1893  | - | - | 0.92 | 4.35 | 2.40 | .0066 | .0470 | .0309 | .0161 | .44 | .0047 | .0001 | .7954 | 0.7 |
| - | 1894* | - | - | 0.94 | 3.95 | 2.06 | .0056 | .0346 | .0240 | .0106 | .47 | .0019 | .0000 | .7884 | 0.6 |
| - | 1895† | - | - | 0.91 | 8.98 | 2.02 | .0125 | .0368 | .0262 | .0106 | .51 | .0043 | .0001 | .7428 | 0.7 |

\* January to June.

† May, June and July.

NOTE to analyses of 1895: Odor, vegetable and unpleasant. — The samples were collected from the pond near the gate-house, 1 foot beneath the surface.

*Microscopical Examination of Water from Walden Pond, Lynn.*

[Number of organisms per cubic centimeter.]

|                               |  | 1895. |        |       |
|-------------------------------|--|-------|--------|-------|
|                               |  | May.  | June.  | July. |
| Day of examination, . . . . . |  | 14    | 13     | 17    |
| Number of sample, . . . . .   |  | 14285 | 14457  | 14635 |
| PLANTS.                       |  |       |        |       |
| Diatomaceæ, . . . . .         |  | 172   | 0      | 0     |
| Asterionella, . . . . .       |  | 156   | 0      | 0     |
| Tabellaria, . . . . .         |  | 16    | 0      | 0     |
| Cyanophyceæ, . . . . .        |  | 0     | 0      | 108   |
| Anabæna, . . . . .            |  | 0     | 0      | 17    |
| Clathrocytis, . . . . .       |  | 0     | 0      | 91    |
| Algæ, . . . . .               |  | 45    | 78,241 | 0     |
| Botryococcus, . . . . .       |  | 2     | 0      | 0     |
| Chlorococcus, . . . . .       |  | 16    | 0      | 0     |
| Protozoococcus, . . . . .     |  | 17    | 78,240 | 0     |
| Raphidium, . . . . .          |  | 3     | 0      | 0     |
| Scenedesmus, . . . . .        |  | 5     | 0      | 0     |
| Staurosira, . . . . .         |  | 2     | 1      | 0     |
| ungi, Orenothrix, . . . . .   |  | 2     | 0      | 0     |



## LYNN AND SAUGUS.

*Microscopical Examination of Water from Walden Pond, Lynn — Concluded.*

[Number of organisms per cubic centimeter.]

|                            |  |  |  |  |  | 1895. |        |       |
|----------------------------|--|--|--|--|--|-------|--------|-------|
|                            |  |  |  |  |  | May.  | June.  | July. |
| <b>ANIMALS.</b>            |  |  |  |  |  |       |        |       |
| <b>Infusoria,</b>          |  |  |  |  |  | 10    | 0      | 15    |
| Dinobryon cases,           |  |  |  |  |  | 7     | 0      | 0     |
| Synura,                    |  |  |  |  |  | 1     | 0      | 0     |
| Trachelomonas,             |  |  |  |  |  | 1     | 0      | 15    |
| Vorticella,                |  |  |  |  |  | 1     | 0      | 0     |
| <b>Vermes,</b>             |  |  |  |  |  | 9     | 0      | 0     |
| Monocerca,                 |  |  |  |  |  | 1     | 0      | 0     |
| Polyarthra,                |  |  |  |  |  | 2     | 0      | 0     |
| Rotifer,                   |  |  |  |  |  | 6     | 0      | 0     |
| <b>Crustacea, Cyclops,</b> |  |  |  |  |  | .03   | 0      | .14   |
| <b>TOTAL,</b>              |  |  |  |  |  | 238   | 78,241 | 123   |

*Chemical Examination of Water from Glen Lewis Pond, Lynn.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                         |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|------------------|-------------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.       | Sediment.               | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                  |                         |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.   |                     |                  |                         |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 13630   | Jan. 8              | Decided.         | Slight.                 | .78    | 4.55                    | 2.00              | .0034    | .0354       | .0242      | .0112      | .58       | .0000       | .0000     | 8346             | 0.8       |
| 13808   | Feb. 12             | V. slight.       | V. slight.              | .55    | 3.90                    | 1.50              | .0102    | .0240       | .0228      | .0012      | .59       | .0030       | .0000     | 5960             | 0.8       |
| 13970   | Mar. 12             | Slight.          | Cons.                   | .25    | 3.15                    | 1.35              | .0144    | .0146       | .0136      | .0010      | .43       | .0050       | .0000     | 5349             | 1.9       |
| 14118   | Apr. 9              | Slight.          | Cons.                   | .50    | 3.55                    | 1.80              | .0036    | .0314       | .0206      | .0108      | .45       | .0040       | .0000     | 4620             | 0.3       |
| 14284   | May 13              | Slight.          | Cons.                   | .45    | 3.55                    | 1.55              | .0000    | .0306       | .0226      | .0080      | .48       | .0030       | .0000     | 5253             | 0.8       |
| 14456   | June 11             | Slight.          | Cons., brown.           | .40    | 3.20                    | 1.45              | .0012    | .0230       | .0184      | .0046      | .50       | .0050       | .0001     | 3978             | 0.3       |
| 14634   | July 16             | Distinct.        | Cons.                   | .53    | 4.30                    | 1.65              | .0004    | .0284       | .0226      | .0058      | .50       | .0050       | .0001     | 4914             | 0.5       |
| 14829   | Aug. 12             | Decided, green.  | Cons., green and brown. | .42    | 3.25                    | 1.35              | .0052    | .0796       | .0318      | .0478      | .48       | .0030       | .0002     | 5694             | 0.5       |
| 15132   | Sept. 9             | Decided, green.  | Heavy, green.           | .28    | 3.60                    | 1.65              | .0028    | .0708       | .0272      | .0434      | .55       | .0000       | .0001     | 6045             | 0.9       |
| 15340   | Oct. 9              | Distinct.        | Cons., green.           | .25    | 4.15                    | 2.20              | .0016    | .0550       | .0366      | .0184      | .56       | .0030       | .0000     | 5366             | 0.8       |
| 15526   | Nov. 12             | Slight, green.   | Slight.                 | .30    | 3.90                    | 2.00              | .0098    | .0372       | .0336      | .0036      | .48       | .0080       | .0001     | 5600             | 0.6       |
| 15711   | Dec. 9              | Distinct, green. | V. slight.              | .37    | 4.15                    | 1.85              | .0106    | .0276       | .0218      | .0058      | .42       | .0030       | .0002     | 5772             | 0.5       |
| Av.     | .....               | .....            | .....                   | .42    | 3.77                    | 1.65              | .0053    | .0381       | .0246      | .0135      | .50       | .0035       | .0001     | 5408             | 0.7       |

*Averages by Years.*

|   |      |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1890 | - | - | .76 | 4.84 | 2.21 | .0412 | .0445 | .0327 | .0118 | .36 | .0063 | .0001 | -     | 1.0 |
| - | 1891 | - | - | .63 | 3.90 | 1.75 | .0328 | .0484 | .0324 | .0160 | .34 | .0124 | .0002 | -     | 0.6 |
| - | 1892 | - | - | .62 | 3.95 | 1.95 | .0127 | .0475 | .0332 | .0143 | .40 | .0193 | .0002 | -     | 0.6 |
| - | 1893 | - | - | .64 | 3.81 | 2.14 | .0112 | .0729 | .0329 | .0400 | .42 | .0040 | .0002 | .6045 | 0.6 |
| - | 1894 | - | - | .85 | 3.81 | 1.89 | .0107 | .0495 | .0297 | .0198 | .44 | .0023 | .0001 | .6869 | 0.5 |
| - | 1895 | - | - | .42 | 3.77 | 1.65 | .0055 | .0381 | .0246 | .0135 | .50 | .0035 | .0001 | .5408 | 0.7 |

NOTE to analyses of 1895: Odor, generally distinctly vegetable and frequently also mouldy, unpleasant or disagreeable.—The samples were collected from the pond near the gate-house, 1 foot beneath the surface.

LYNN AND SAUGU

*Microscopical Examination of Water from Glen Lewis Pond, Lynn.*

[Number of organisms per cubic centimeter.]

|                           | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                           | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Way of examination, . . . | 9     | 14    | 14    | 10    | 14    | 12    | 17    | 15    | 12    | 10    | 14    | 12    |
| Number of sample, . . .   | 13630 | 13808 | 13970 | 14118 | 14284 | 14456 | 14634 | 14829 | 15132 | 15340 | 15526 | 15711 |
| PLANTS.                   |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .         | 0     | 0     | 0     | 3     | 612   | 1     | 6     | 0     | 50    | 150   | 15    | 21    |
| Asterionella, . . .       | 0     | 0     | 0     | 0     | 260   | 0     | 1     | 0     | 0     | 0     | 0     | 0     |
| Fragilaria, . . .         | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 10    |
| Melosira, . . .           | 0     | 0     | 0     | 2     | 340   | 0     | 5     | 0     | 0     | 150   | 12    | 0     |
| Synedra, . . .            | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 50    | 0     | 3     | 3     |
| Tabellaria, . . .         | 0     | 0     | 0     | 1     | 12    | 0     | 0     | 0     | 0     | 0     | 0     | 8     |
| Cyanophyceæ, . . .        | 4     | 0     | 3     | 0     | 47    | 5     | 164   | 4,150 | 2,000 | 450   | 24    | 8     |
| Anabaena, . . .           | 0     | 0     | 0     | 0     | 0     | 1     | 96    | 3,900 | 1,700 | 350   | 16    | 0     |
| Chroococcus, . . .        | 0     | 0     | 0     | 0     | 45    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Clathrocystis, . . .      | 4     | 0     | 3     | 0     | 1     | 0     | 60    | 200   | 250   | 100   | 8     | 9     |
| Celosphaerium, . . .      | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 50    | 50    | 0     | 0     | 0     |
| Microcystis, . . .        | 0     | 0     | 0     | 0     | 1     | 4     | 6     | 0     | 0     | 0     | 0     | 0     |
| Algae, . . .              | 0     | 0     | 0     | 6     | 53    | 132   | 8     | 0     | 50    | 100   | 29    | 5     |
| Arthrodesmus, . . .       | 0     | 0     | 0     | 0     | 0     | 5     | 0     | 0     | 0     | 0     | 0     | 1     |
| Chlorococcus, . . .       | 0     | 0     | 0     | 0     | 40    | 0     | 1     | 0     | 0     | 0     | 0     | 0     |
| Pediastrum, . . .         | 0     | 0     | 0     | 0     | 1     | 1     | 5     | 0     | 0     | 0     | 0     | 0     |
| Protococcus, . . .        | 0     | 0     | 0     | 0     | 0     | 109   | 0     | 0     | 0     | 0     | 4     | 4     |
| Raphidium, . . .          | 0     | 0     | 0     | 0     | 2     | 0     | 1     | 0     | 0     | 0     | 20    | 0     |
| Staurostrum, . . .        | 0     | 0     | 0     | 0     | 10    | 17    | 1     | 0     | 50    | 100   | 5     | 0     |
| Zoo-spores, . . .         | 0     | 0     | 0     | 6     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| ungi, Crenothrix, . . .   | 0     | 0     | 0     | 1     | 2     | 17    | 11    | 0     | 0     | 0     | 2     | 0     |
| ANIMALS.                  |       |       |       |       |       |       |       |       |       |       |       |       |
| Isoria, . . .             | 0     | 133   | 0     | 120   | 665   | 0     | 8     | 200   | 100   | 0     | 12    | 236   |
| Unated infusorian, . . .  | 0     | 0     | 0     | 23    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Inobryon, . . .           | 0     | 0     | 0     | 46    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 146   |
| Inobryon cases, . . .     | 0     | 124   | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Iglena, . . .             | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     |
| Ilomonas, . . .           | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 13    |
| Idinium, . . .            | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 150   | 100   | 0     | 0     | 0     |
| Idinium, . . .            | 0     | 6     | 0     | 40    | 0     | 0     | 1     | 0     | 0     | 0     | 2     | 76    |
| Chelomonas, . . .         | 0     | 2     | 0     | 1     | 660   | 0     | 7     | 50    | 0     | 0     | 10    | 0     |
| Iglena, . . .             | 0     | 0     | 0     | 6     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Is, . . .                 | 0     | 1     | 0     | 0     | 15    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Iccerca, . . .            | 0     | 1     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Urthra, . . .             | 0     | 0     | 0     | 0     | 15    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Cous, . . .               | 0     | 0     | 0     | 0     | 6     | 0     | .20   | 0     | 0     | 0     | 0     | 0     |
| Is, . . .                 | 0     | 0     | 0     | 0     | .01   | 0     | .20   | 0     | 0     | 0     | 0     | 0     |
| Is, . . .                 | 0     | 0     | 0     | 0     | 6     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| . . . . .                 | 4     | 134   | 3     | 130   | 1,400 | 155   | 197   | 4,860 | 2,200 | 700   | 82    | 271   |

## LYNN AND SAUGUS.

*Chemical Examination of Water from the Saugus River at Howlett's Dam, Saugus.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------|--------|-------------------------|-------------------|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                   |        |                         |                   |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |           |
| 1895.   |                     |             |                   |        |                         |                   |          |             |            |                 |           |             |           |                  |           |
| 13632   | Jan. 8              | Slight.     | Slight.           | 1.40   | 9.50                    | 4.10              | .0106    | .0344       | .0334      | .0010           | .97       | .0200       | .0003     | 1.5210           | 3.9       |
| 13809   | Feb. 12             | V. slight.  | V. slight.        | 1.25   | 9.70                    | 3.20              | .0142    | .0298       | .0286      | .0012           | 1.03      | .0250       | .0003     | 1.4800           | 4.2       |
| 13971   | Mar. 12             | V. slight.  | Slight.           | 0.85   | 6.25                    | 2.45              | .0064    | .0230       | .0206      | .0024           | .60       | .0220       | .0005     | 0.7839           | 2.1       |
| 14119   | Apr. 9              | V. slight.  | Slight.           | 0.90   | 5.80                    | 2.55              | .0048    | .0250       | .0238      | .0012           | .54       | .0120       | .0002     | 0.8162           | 1.9       |
| 14286   | May 13              | V. slight.  | Cons.             | 2.55   | 8.75                    | 3.95              | .0148    | .0510       | .0482      | .0028           | .74       | .0100       | .0007     | 2.2514           | 3.0       |
| 14458   | June 11             | Slight.     | Cons.,<br>brown.  | 1.16   | 7.25                    | 3.85              | .0034    | .0342       | .0290      | .0052           | .88       | .0070       | .0006     | 0.9890           | 2.5       |
| 14636   | July 16             | Slight.     | Slight.           | 1.35   | 8.85                    | 4.00              | .0018    | .0496       | .0446      | .0050           | 1.05      | .0050       | .0001     | 1.0140           | 3.4       |
| 14830   | Aug. 12             | Slight.     | Slight,<br>rusty. | 1.90   | 9.60                    | 4.90              | .0036    | .0620       | .0548      | .0072           | .90       | .0070       | .0001     | 2.5740           | 3.1       |
| 15133   | Sept. 9             | Distinct.   | Slight.           | 0.95   | 9.65                    | 4.40              | .0106    | .0402       | .0380      | .0022           | 1.35      | .0020       | .0001     | 1.0452           | 3.5       |
| 15341   | Oct. 9              | V. slight.  | Slight.           | 0.65   | 9.40                    | 3.45              | .0000    | .0340       | .0286      | .0054           | 1.49      | .0000       | .0000     | 0.7644           | 4.4       |
| 15527   | Nov. 12             | V. slight.  | V. slight.        | 1.30   | 8.00                    | 3.40              | .0048    | .0388       | .0362      | .0026           | .92       | .0800       | .0005     | 1.2542           | 2.7       |
| 15712   | Dec. 9              | V. slight.  | V. slight.        | 1.25   | 7.25                    | 3.25              | .0016    | .0350       | .0328      | .0022           | .77       | .0100       | .0002     | 1.2245           | 2.9       |
| Av.     | 1895                | .....       | .....             | 1.29   | 8.33                    | 3.62              | .0064    | .0381       | .0349      | .0032           | .94       | .0125       | .0003     | 1.3098           | 3.1       |
| Av.     | 1894                | .....       | .....             | 1.16   | 8.68                    | 3.36              | .0056    | .0310       | .0272      | .0038           | 1.03      | .0112       | .0014     | 0.9529           | 3.5       |

NOTE to analyses of 1895: Odor, vegetable, and frequently mouldy or unpleasant. — The samples were collected from the river at Howlett's Dam.

*Chemical Examination of Water from the Saugus River at the Line between Saugus and Wakefield, and just above the Point where it is joined by the Wakefield Branch.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |  |
|---------|---------------------|-------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|--|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |  |
|         |                     |             |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |  |
| 1895.   |                     |             |                   |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |  |
| 13633   | Jan. 8              | Slight.     | Slight.           | 1.55   | 9.55                            | 3.70                 | .0062    | .0376       | .0366      | .0010           | .86       | .0030          | .0000     | 1.6770           | 4.0       |  |
| 13810   | Feb. 12             | V. slight.  | Slight.           | 1.40   | 9.90                            | 3.80                 | .0060    | .0324       | .0322      | .0002           | .91       | .0030          | .0000     | 1.6000           | 4.7       |  |
| 13972   | Mar. 12             | V. slight.  | Cons.             | 0.90   | 5.90                            | 2.50                 | .0014    | .0220       | .0200      | .0020           | .53       | .0050          | .0001     | 0.8701           | 2.1       |  |
| 14120   | Apr. 9              | V. slight.  | Cons.,<br>earthy. | 0.85   | 4.35                            | 1.90                 | .0030    | .0222       | .0180      | .0042           | .50       | .0150          | .0001     | 0.7069           | 1.3       |  |
| 14287   | May 13              | V. slight.  | Cons.             | 2.40   | 8.60                            | 4.40                 | .0026    | .0496       | .0444      | .0052           | .68       | .0050          | .0001     | 2.5280           | 3.0       |  |
| 14459   | June 11             | V. slight.  | Cons.             | 1.30   | 5.65                            | 2.35                 | .0008    | .0320       | .0306      | .0014           | .72       | .0030          | .0001     | 1.1739           | 2.9       |  |
| 14637   | July 16             | V. slight.  | Slight.           | 1.80   | 7.95                            | 4.10                 | .0010    | .0445       | .0436      | .0010           | .67       | .0050          | .0001     | 1.7160           | 3.2       |  |
| 14831   | Aug. 12             | V. slight.  | V. slight.        | 1.90   | 9.35                            | 4.70                 | .0028    | .0508       | .0480      | .0028           | .66       | .0030          | .0002     | 2.1450           | 3.6       |  |
| 15135   | Sept. 9             | Distinct.   | Slight.           | 1.00   | 8.65                            | 3.45                 | .0026    | .0310       | .0294      | .0016           | .88       | .0000          | .0001     | 1.0920           | 4.0       |  |
| 15342   | Oct. 9              | V. slight.  | V. slight.        | 0.80   | 8.55                            | 3.00                 | .0008    | .0336       | .0306      | .0030           | .83       | .0000          | .0000     | 0.9149           | 4.8       |  |
| 15528   | Nov. 12             | V. slight.  | Slight.           | 1.40   | 6.60                            | 3.20                 | .0012    | .0390       | .0368      | .0022           | .54       | .0080          | .0000     | 1.4547           | 2.5       |  |
| 15713   | Dec. 9              | V. slight.  | V. slight.        | 1.35   | 7.40                            | 3.35                 | .0004    | .0356       | .0328      | .0028           | .72       | .0020          | .0000     | 1.3026           | 2.9       |  |
| Av.     | 1895                | .....       | .....             | 1.39   | 7.70                            | 3.37                 | .0024    | .0359       | .0336      | .0023           | .71       | .0043          | .0001     | 1.4318           | 3.2       |  |
| Av.     | 1894                | .....       | .....             | 1.18   | 7.71                            | 3.00                 | .0017    | .0288       | .0260      | .0027           | .62       | .0038          | .0000     | 1.0063           | 3.2       |  |

NOTE to analyses of 1895: Odor, in January, decidedly disagreeable; at other times, vegetable and sometimes also mouldy. — The samples were collected from the Saugus River, at a road crossing at the upper end of Howlett's Pond, just above the point where the river is joined by the Wakefield branch.



## LYNN AND SAUGUS.

*Microscopical Examination of Water from a Faucet in Lynn—Concluded.*

[Number of organisms per cubic centimeter.]

|                                   | 1895. |      |      |      |     |      |      |       |      |      |      |      |
|-----------------------------------|-------|------|------|------|-----|------|------|-------|------|------|------|------|
|                                   | Jan.  | Feb. | Mar. | Apr. | May | June | July | Aug.  | Sept | Oct. | Nov. | Dec. |
| <b>ANIMALS.</b>                   |       |      |      |      |     |      |      |       |      |      |      |      |
| Infusoria, . . . . .              | 2     | 0    | 1    | 3    | 0   | 0    | 68   | 39    | 60   | 5    | 10   | 4    |
| Ciliated Infusorian, . . . . .    | 0     | 0    | 0    | 0    | 0   | 0    | 7    | 0     | 0    | 0    | 0    | 0    |
| Cryptomonas, . . . . .            | 2     | 0    | 0    | 0    | 0   | 0    | 0    | 0     | 0    | 0    | 0    | 0    |
| Dinobryon, . . . . .              | 0     | 0    | 0    | 0    | 0   | 0    | 0    | 0     | 0    | 0    | 9    | 0    |
| Dinobryon cases, . . . . .        | 0     | 0    | 0    | 0    | 0   | 0    | 21   | 32    | 32   | 0    | 0    | 0    |
| Mallomonas, . . . . .             | 0     | 0    | 0    | 0    | 0   | 0    | 0    | 0     | 0    | 1    | 1    | 0    |
| Monas, . . . . .                  | 0     | 0    | 0    | 0    | 0   | 0    | 0    | 0     | 0    | 0    | 0    | 4    |
| Peridinium, . . . . .             | 0     | 0    | 1    | 3    | 0   | 0    | 4    | 0     | 0    | 0    | 0    | 0    |
| Trachelomonas, . . . . .          | 0     | 0    | 0    | 0    | 0   | 0    | 36   | 7     | 28   | 4    | 0    | 0    |
| Miscellaneous, Zoöglæa, . . . . . | 0     | 0    | 0    | 0    | 0   | 0    | 0    | 0     | 200  | 600  | 100  | 0    |
| <b>TOTAL,</b> . . . . .           | 138   | 4    | 18   | 13   | 143 | 292  | 331  | 1,014 | 643  | 834  | 190  | 19   |

*Chemical Examination of Water from Cedar Brook above Sluice Pond, Lynn.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN<br>as |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |                |           |                  |           |
| 13689   | 1895.<br>Jan. 17    | V. slight.  | Slight.   | .67    | 3.80                    | 1.70              | .0002    | .0098       | .0082      | .0016      | .49       | .0050          | .0000     | .5672            | 0.6       |

Odor, very faintly vegetable, becoming stronger on heating.

*Microscopical Examination.*Diatomaceæ, *Fragilaria*, 4; *Synedra*, 1. Fungi, *Crenothrix*, 1. Total, 6.

Table showing Monthly Depth of Water in Feet in the Ponds and Storage Reservoirs of the Lynn Water Works during the Year 1895.

|                    | Breed's Pond.              |  | Birch Pond.                 |  | Walden Pond.               |  | Olen Lewis Pond.            |  |
|--------------------|----------------------------|--|-----------------------------|--|----------------------------|--|-----------------------------|--|
|                    | High Water,<br>21.50 Feet. |  | High Water,<br>21.50 Feet.* |  | High Water,<br>17.00 Feet. |  | High Water,<br>17 00 Feet.* |  |
| Jan. 1, . . . . .  | 11.92                      |  | 14.67                       |  | —                          |  | 15.50                       |  |
| Feb. 2, . . . . .  | 14.04                      |  | 17.75                       |  | —                          |  | 16.79                       |  |
| March 4, . . . . . | 13.71                      |  | 17.92                       |  | —                          |  | 17.42                       |  |
| April 1, . . . . . | 16.17                      |  | 19.08                       |  | 11.08                      |  | 17.50                       |  |
| May 6, . . . . .   | 19.63                      |  | 22.17                       |  | 14.33                      |  | 17.50                       |  |
| June 1, . . . . .  | 20.63                      |  | 22.54                       |  | 13.50                      |  | 17.42                       |  |
| July 1, . . . . .  | 20.60                      |  | 22.17                       |  | 9.83                       |  | 17.42                       |  |
| Aug. 1, . . . . .  | 20.13                      |  | 18.33                       |  | 4.00                       |  | 17.46                       |  |
| Sept. 2, . . . . . | 19.75                      |  | 12.75                       |  | —                          |  | 17.46                       |  |
| Oct. 1, . . . . .  | 18.92                      |  | 7.00                        |  | —                          |  | 17.42                       |  |
| Nov. 2, . . . . .  | 17.00                      |  | 8.75                        |  | —                          |  | 18.13                       |  |
| Dec. 1, . . . . .  | 20.08                      |  | 18.92                       |  | —                          |  | 18.00                       |  |

\* The water in these ponds is sometimes raised somewhat above ordinary high water.

## MALDEN, MEDFORD AND MELROSE.

## WATER SUPPLY OF MALDEN, MEDFORD AND MELROSE.

*Chemical Examination of Water from Spot Pond, Stoneham.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.       | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |             |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                 |        |                         |                   |          | Total.      | Dissolved. | Sus-pended. |           |             |           |                  |           |
| 1895.   |                     |             |                 |        |                         |                   |          |             |            |             |           |             |           |                  |           |
| 13601   | Jan. 3              | Slight.     | Slight.         | .30    | 7.20                    | 2.30              | .0032    | .0238       | .0220      | .0018       | .69       | .0040       | .0000     | .3619            | 3.2       |
| 13719   | Jan. 25             | None.       | V. slight.      | .20    | 6.95                    | 1.60              | .0050    | .0204       | .0188      | .0016       | .70       | .0170       | .0000     | .3120            | 2.7       |
| 13732   | Jan. 28             | V. slight.  | V. slight.      | .18    | 5.90                    | 1.55              | .0020    | .0176       | .0138      | .0038       | .68       | .0170       | .0001     | .3476            | 2.5       |
| 13780   | Feb. 5              | V. slight.  | V. slight.      | .15    | 7.10                    | 1.85              | .0030    | .0198       | .0176      | .0022       | .72       | .0180       | .0000     | .3318            | 2.7       |
| 13942   | Mar. 5              | Distinct.   | Cons.           | .12    | 5.70                    | 1.85              | .0150    | .0202       | .0184      | .0018       | .58       | .0180       | .0000     | .3296            | 2.7       |
| 14099   | Apr. 2              | Slight.     | Slight.         | .28    | 5.30                    | 1.50              | .0076    | .0162       | .0148      | .0014       | .58       | .0170       | .0000     | .4312            | 2.6       |
| 14269   | May 6               | V. slight.  | Cons.           | .23    | 5.20                    | 1.80              | .0052    | .0170       | .0156      | .0014       | .58       | .0120       | .0001     | .4273            | 2.2       |
| 14437   | June 3              | Slight.     | Slight, yellow. | .28    | 5.50                    | 2.25              | .0066    | .0228       | .0210      | .0018       | .59       | .0030       | .0001     | .4940            | 2.2       |
| 14606   | July 9              | Distinct.   | Cons.           | .23    | 6.30                    | 2.10              | .0002    | .0308       | .0276      | .0032       | .59       | .0030       | .0000     | .5372            | 2.3       |
| 14781   | Aug. 5              | Distinct.   | Cons.           | .25    | 5.75                    | 2.25              | .0006    | .0226       | .0190      | .0036       | .60       | .0080       | .0000     | .4992            | 2.5       |
| 15049   | Sept. 4             | Distinct.   | Slight.         | .20    | 6.00                    | 2.10              | .0026    | .0232       | .0202      | .0030       | .64       | .0020       | .0001     | .4540            | 2.7       |
| 15313   | Oct. 3              | V. slight.  | Cons.           | .23    | 5.60                    | 2.00              | .0030    | .0212       | .0190      | .0022       | .62       | .0000       | .0000     | .3806            | 2.5       |
| 15594   | Nov. 19             | V. slight.  | V. slight.      | .38    | 6.30                    | 2.35              | .0082    | .0268       | .0238      | .0030       | .59       | .0130       | .0001     | .5031            | 2.2       |
| 15703   | Dec. 8              | V. slight.  | Slight.         | .40    | 5.65                    | 2.40              | .0142    | .0222       | .0206      | .0016       | .50       | .0080       | .0001     | .5226            | 2.1       |
| Av*     | .....               | .....       | .....           | .25    | 5.92                    | 2.02              | .0058    | .0210       | .0196      | .0023       | .61       | .0096       | .0000     | .4376            | 2.4       |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887† | - | - | .25 | 4.35 | 1.24 | .0004 | .0207 | -     | -     | .46 | .0025 | -     | -     | -   |
| - | 1888  | - | - | .22 | 3.98 | 1.24 | .0007 | .0225 | -     | -     | .44 | .0054 | .0001 | -     | -   |
| - | 1889  | - | - | .26 | 3.54 | 1.17 | .0017 | .0236 | .0198 | .0038 | .44 | .0053 | .0002 | -     | -   |
| - | 1890  | - | - | .24 | 3.96 | 1.24 | .0019 | .0220 | .0180 | .0040 | .42 | .0066 | .0001 | -     | 1.7 |
| - | 1891  | - | - | .21 | 3.70 | 1.27 | .0008 | .0183 | .0161 | .0022 | .43 | .0082 | .0001 | -     | 1.4 |
| - | 1892  | - | - | .17 | 4.28 | 1.30 | .0035 | .0198 | .0157 | .0041 | .50 | .0081 | .0001 | -     | 1.7 |
| - | 1893  | - | - | .29 | 5.70 | 1.71 | .0085 | .0197 | .0162 | .0035 | .49 | .0105 | .0003 | .3486 | 2.4 |
| - | 1894  | - | - | .23 | 5.90 | 1.68 | .0029 | .0210 | .0160 | .0050 | .57 | .0039 | .0001 | .3616 | 2.4 |
| - | 1895  | - | - | .25 | 5.92 | 2.02 | .0058 | .0219 | .0196 | .0023 | .61 | .0096 | .0000 | .4376 | 2.4 |

\* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

† May to December.

NOTE to analyses of 1895: Odor, generally vegetable, sometimes also disagreeable, rarely none.  
— The samples were collected from the pond.

## MALDEN, MEDFORD AND MELROSE.

*Microscopical Examination of Water from Spot Pond, Stoneham.*

[Number of organisms per cubic centimeter.]

|                         | 1895. |       |       |       |       |       |       |       |       |       |       |       |       |       |
|-------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                         | Jan.  | Jan.  | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, .   | 5     | 29    | 31    | 9     | 8     | 6     | 10    | 8     | 12    | 10    | 10    | 8     | 23    | 12    |
| Number of sample, .     | 13601 | 13719 | 13732 | 13780 | 13942 | 14099 | 14269 | 14437 | 14606 | 14781 | 15049 | 15313 | 15594 | 15703 |
| PLANTS.                 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . .         | 13    | 0     | 2     | pr.   | 0     | 0     | 350   | 994   | 11    | 38    | 165   | 40    | 105   | 159   |
| Asterionella, . .       | 8     | 0     | 0     | 0     | 0     | 0     | 36    | 574   | 0     | 0     | 164   | 28    | 13    | 41    |
| Cyclotella, . .         | 1     | 0     | 2     | 0     | 0     | 0     | 150   | 418   | 2     | 4     | 1     | 0     | 2     | 2     |
| Melosira, . .           | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 12    | 2     | 26    |
| Synedra, . .            | 2     | 0     | 0     | pr.   | 0     | 0     | 156   | 2     | 3     | 32    | 0     | 0     | 0     | 0     |
| Tabellaria, . .         | 2     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 6     | 2     | 0     | 0     | 88    | 90    |
| Cyanophyceæ.            |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Anabaena, . .           | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 108   | 1     | 0     | 0     | 0     | 0     |
| Algae, . . . .          |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Protococcus, . .        | 0     | 0     | 0     | 0     | 0     | 0     | 18    | 0     | 146   | 17    | 0     | 24    | 0     | 0     |
| Raphidium, . .          | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 3     | 3     | 4     | 3     | 1     |
| Scenedesmus, . .        | 0     | 0     | 0     | 0     | 0     | 0     | 9     | 0     | 3     | 0     | 0     | 0     | 0     | 0     |
| Fungi, Crenothrix, .    | 0     | 0     | 1     | 0     | 1     | 2     | 3     | 5     | 6     | 32    | 2     | 14    | 5     | 3     |
| ANIMALS.                |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . .        | 29    | 1     | 2     | 7     | 10    | 1     | 4     | 0     | 45    | 7     | 4     | 129   | 1     | 0     |
| Dinobryon, . .          | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 3     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, .      | 0     | 0     | 0     | 0     | 0     | 1     | 4     | 0     | 0     | 0     | 0     | 126   | 0     | 0     |
| Peridinium, . .         | 1     | 1     | 2     | 7     | 9     | 0     | 0     | 0     | 36    | 7     | 4     | 0     | 0     | 0     |
| Trachelomonas, .        | 1     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 4     | 0     | 0     | 3     | 1     | 0     |
| Uroglena, . . .         | 27    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     |
| Miscellaneous, Zoöglæa, | 0     | 0     | 0     | 0     | 0     | 48    | 40    | 0     | 0     | 0     | 0     | 0     | 5     | 20    |
| TOTAL, . . . .          | 42    | 1     | 5     | 7     | 11    | 51    | 424   | 999   | 323   | 98    | 174   | 211   | 119   | 183   |

Table showing Heights of Water in Spot Pond on the First of Each Month in 1895.

| DATE.              | Distance<br>Below High-<br>water Mark. | DATE.              | Distance<br>Below High-<br>water Mark. |
|--------------------|----------------------------------------|--------------------|----------------------------------------|
| Jan. 1, . . . . .  | Feet.<br>7.19                          | July 1, . . . . .  | Feet.<br>3.27                          |
| Feb. 1, . . . . .  | 6.04                                   | Aug. 1, . . . . .  | 4.08                                   |
| March 1, . . . . . | 6.15                                   | Sept. 1, . . . . . | 4.94                                   |
| April 1, . . . . . | 4.02                                   | Oct. 1, . . . . .  | 6.19                                   |
| May 1, . . . . .   | 2.50                                   | Nov. 1, . . . . .  | 5.35                                   |
| June 1, . . . . .  | 2.44                                   | Dec. 1, . . . . .  | 2.39                                   |

## MALDEN.

## WATER SUPPLY OF MALDEN.

*Chemical Examination of Water from Tubular Wells at Maplewood (Webster Park), Malden.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |                 |        | Residue on Evaporation. | AMMONIA. |           | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------------------|-------------|-----------------|--------|-------------------------|----------|-----------|-----------|-------------|-----------|------------------|-----------|-------|
|                     | Turbidity.  | Sediment.       | Color. |                         | Free.    | Albimoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| <b>1895.</b>        |             |                 |        |                         |          |           |           |             |           |                  |           |       |
| Jan. 3              | None.       | None.           | .01    | 29.20                   | .0004    | .0020     | 2.78      | .3750       | .0000     | .0038            | 15.8      | .0040 |
| Feb. 5              | None.       | None.           | .01    | 29.40                   | .0000    | .0016     | 2.55      | .4500       | .0000     | .0118            | 15.0      | .0020 |
| Mar. 5              | None.       | None.           | .00    | 31.90                   | .0000    | .0018     | 2.40      | .4000       | .0000     | .0200            | 16.0      | .0000 |
| Apr. 2              | Slight.     | Slight.         | .02    | 32.20                   | .0004    | .0010     | 2.60      | .4900       | .0000     | .0400            | 12.4      | .0340 |
| May 6               | V. slight.  | Slight, earthy. | .00    | 32.60                   | .0000    | .0028     | 2.60      | .4500       | .0000     | .0038            | 13.0      | .0140 |
| June 3              | None.       | None.           | .00    | 34.20                   | .0000    | .0022     | 2.70      | .3650       | .0001     | .0342            | 13.0      | .0050 |
| July 9              | None.       | None.           | .00    | 33.10                   | .0002    | .0020     | 2.70      | .5250       | .0000     | .0395            | 12.9      | .0020 |
| Aug. 5              | None.       | None.           | .00    | 33.80                   | .0000    | .0010     | 2.90      | .5000       | .0000     | .0390            | 17.5      | .0050 |
| Sept. 4             | None.       | None.           | .00    | 35.00                   | .0000    | .0006     | 3.00      | .4000       | .0001     | .0819            | 14.5      | .0320 |
| Oct. 3              | None.       | V. slight.      | .02    | 30.50                   | .0000    | .0006     | 2.95      | .4750       | .0000     | .0273            | 16.4      | .0050 |
| Nov. 19             | None.       | None.           | .00    | 31.50                   | .0000    | .0014     | 2.81      | .4500       | .0000     | .0390            | 15.9      | .0030 |
| Dec. 8              | None.       | V. slight.      | .00    | 30.90                   | .0000    | .0014     | 2.74      | .3000       | .0000     | .0429            | 16.0      | .0050 |
| .....               | .....       | .....           | .00    | 32.02                   | .0001    | .0015     | 2.73      | .4317       | .0000     | .0319            | 14.9      | .0092 |

*Averages by Years.*

|       |   |   |     |       |       |       |      |       |       |       |      |       |
|-------|---|---|-----|-------|-------|-------|------|-------|-------|-------|------|-------|
| 1887* | - | - | .00 | 17.03 | .0000 | .0008 | 2.20 | .4050 | -     | -     | -    | -     |
| 1888  | - | - | .00 | 17.45 | .0000 | .0003 | 2.30 | .5081 | -     | -     | -    | -     |
| 1889† | - | - | .00 | 16.95 | .0001 | .0031 | 1.76 | .5500 | .0001 | -     | 7.3  | -     |
| 1890  | - | - | .00 | 18.19 | .0002 | .0014 | 2.30 | .4904 | .0001 | -     | 8.0  | -     |
| 1891  | - | - | .00 | 20.83 | .0001 | .0007 | 2.23 | .5146 | .0001 | -     | 9.6  | -     |
| 1892  | - | - | .00 | 23.00 | .0000 | .0005 | 2.36 | .5129 | .0000 | -     | 11.4 | -     |
| 1893  | - | - | .00 | 23.72 | .0001 | .0011 | 2.48 | .4823 | .0000 | .0186 | 11.1 | .0033 |
| 1894  | - | - | .00 | 28.23 | .0000 | .0012 | 2.74 | .3946 | .0000 | .0172 | 13.2 | .0058 |
| 1895  | - | - | .00 | 32.02 | .0001 | .0015 | 2.73 | .4317 | .0000 | .0319 | 14.9 | .0092 |

\* Three samples in November and December.

† June and October.

For analyses of 1898: Odor, none. — The samples were collected from a faucet at the pumping station.

*Microscopical Examination.*

A small number of organisms, chiefly *Oreothrix* and *Zodglexa*, was found in some of these samples.



## MANCHESTER.

## WATER SUPPLY OF MANCHESTER.

The works for obtaining a supply of water for the town of Manchester were extended in 1895 by sinking five 4-inch tubular wells in the valley of Sawmill Brook near Coolidge Spring, a short distance above the large well. The wells were driven to depths ranging from 27 to 34 feet, and water is pumped from them through a 6-inch pipe into the large well near the pumping station.

*Chemical Examination of Water from the Well of the Manchester Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 13705   | 1895.<br>Jun. 23    | None.       | None.      | .02    | 10.00                   | .0000    | .0002       | 1.89      | .0800       | .0000     | .0047            | 3.5       | .0070 |
| 14208   | Apr. 23             | None.       | V. slight. | .00    | 10.20                   | .0002    | .0010       | 1.94      | .0730       | .0000     | .0197            | 3.5       | .0010 |
| 14835   | Aug. 13             | None.       | Slight.    | .00    | 9.70                    | .0000    | .0000       | 1.82      | .0750       | .0001     | .0234            | 2.9       | .0080 |
| 15422   | Oct. 24             | None.       | None.      | .00    | 9.60                    | .0004    | .0008       | 1.76      | .0870       | .0000     | .0195            | 3.4       | .0000 |
| Av.     | .....               | .....       | .....      | .01    | 9.87                    | .0001    | .0005       | 1.80      | .0737       | .0000     | .0168            | 3.3       | .0040 |

*Averages by Years.*

|   |      |   |   |     |      |       |       |      |       |       |       |     |       |
|---|------|---|---|-----|------|-------|-------|------|-------|-------|-------|-----|-------|
| - | 1892 | - | - | .00 | 9.38 | .0001 | .0003 | 1.75 | .1214 | .0001 | -     | 3.4 | -     |
| - | 1893 | - | - | .00 | 9.64 | .0000 | .0002 | 1.69 | .0975 | .0000 | .0370 | 3.5 | .0006 |
| - | 1894 | - | - | .00 | 9.82 | .0000 | .0006 | 1.82 | .0700 | .0000 | .0066 | 3.4 | .0010 |
| - | 1895 | - | - | .01 | 9.87 | .0001 | .0005 | 1.80 | .0737 | .0000 | .0168 | 3.3 | .0040 |

Odor, none. — The samples were collected from the well.

*Microscopical Examination.*

No organisms.

*Chemical Examination of Water from Tubular Wells near Coolidge Spring, used as an Additional Source of Water Supply for Manchester.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 14834   | 1895.<br>Aug. 13    | None.       | None.     | .00    | 8.70                    | .0000    | .0002       | 1.42      | .2000       | .0001     | .0390            | 2.7       | .0000 |

Odor, none. — The sample was collected from a pump drawing water from the wells.

*Microscopical Examination.*

No organisms.

## MANCHESTER.

*Chemical Examination of Water from Cat Brook.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 14367   | 1895.<br>May 24     | V. slight.  | Cons.     | 1.20   | 4.95                    | 2.55              | .0000    | .0146       | .0130      | .0016      | .92       | .0000       | .0000     | .9880            | 0.5       |

Odor, decidedly vegetable. — The sample was collected from the brook, about half a mile above the pumping station of the Manchester water works.

*Microscopical Examination.*

An insignificant number of organisms was found in this sample.

## WATER SUPPLY OF MANSFIELD WATER SUPPLY DISTRICT, MANSFIELD.

*Chemical Examination of Water from the Well of the Mansfield Water Works.*

[Parts per 100,000.]

| Number. | Date of<br>Collection. | APPEARANCE. |           |        | Residue on<br>Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN<br>AS |           | Oxygen<br>Consumed. | Hardness. | Iron. |
|---------|------------------------|-------------|-----------|--------|----------------------------|----------|------------------|-----------|----------------|-----------|---------------------|-----------|-------|
|         |                        | Turbidity.  | Sediment. | Color. |                            | Free.    | Albu-<br>minoid. |           | Nitrates.      | Nitrites. |                     |           |       |
|         |                        |             |           |        |                            |          |                  |           |                |           |                     |           |       |
| 14585   | 1895.<br>July 8        | None.       | None.     | .00    | 2.60                       | .0000    | .0000            | .31       | .0070          | .0000     | .0237               | 0.5       | .0000 |

Odor, none. — The sample was collected from a faucet at the pumping station.

*Microscopical Examination.*

No organisms.

## WATER SUPPLY OF MARBLEHEAD.

During the year 1895 the small collecting well which was built in 1893 near a small pond in the vicinity of the pumping station was replaced by a large well constructed in the bed of the pond. The well is 25 feet in diameter and 34 feet deep, and is sunk through about 20 feet of mud into a bed of gravel. Water from this well is used at the times when the quantity of water furnished by the original well is insufficient for the supply of the town.

**MARBLEHEAD.***Chemical Examination of Water from Faucets in Marblehead supplied from the Marblehead Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |            |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|------------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment.  | Color. |                         | Free.    | Alb. minhold. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1895.</b>        |                  |            |        |                         |          |               |           |             |           |                  |           |       |
| 13980   | Mar. 14             | None.            | None.      | .02    | 13.40                   | .0014    | .0032         | 2.26      | .0360       | .0000     | .0360            | 6.6       | .0120 |
| 14309   | May 15              | Slight.          | None.      | .04    | 14.70                   | .0000    | .0014         | 2.00      | .0480       | .0000     | .0158            | 7.0       | .0120 |
| 14810   | May 15              | V. slight.       | None.      | .04    | 15.80                   | .0000    | .0014         | 2.10      | .0380       | .0000     | .0253            | 6.6       | .0020 |
| 14709   | July 25             | Distinct, milky. | Slight.    | .10    | 14.60                   | .0040    | .0016         | 2.30      | .0150       | .0000     | .0385            | 7.1       | .0330 |
| 15252   | Sept. 24            | Slight, milky.   | V. slight. | .10    | 15.10                   | .0000    | .0010         | 2.10      | .0350       | .0000     | .0000            | 6.4       | .0200 |
| 15620   | Nov. 25             | V. slight.       | V. slight. | .03    | 16.90                   | .0000    | .0006         | 2.60      | .0520       | .0000     | .0507            | 8.4       | .0040 |
| Av.*    | .....               | .....            | .....      | .06    | 15.05                   | .0011    | .0016         | 2.27      | .0350       | .0000     | .0291            | 7.1       | .0152 |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

Odor of the first sample, faintly musty; of the others, none.

*Microscopical Examination.*

No organisms.

**WATER SUPPLY OF MARLBOROUGH.**

During 1895 a storage reservoir was constructed on Millham Brook near its junction with the Assabet River, and a short distance below the point from which water has been pumped during a portion of the last two years for the supply of the city. The reservoir has an area of about 66 acres, and its general depth is about 25 feet. Its total storage capacity when full is 315,000,000 gallons, but by the present arrangement the available capacity above the entrance to the pipe leading to the pumping station, which is 14 feet below high water, is about 262,000,000 gallons. The area flowed contained a meadow having an area of about 30 acres, where the mud was from 3 to 6 feet in depth. The mud was not disturbed, and the only preparation which the surface received was the burning of the grass. The bottom of the reservoir at the sides was stripped of loam and vegetable matter above a level 10 feet below high water, and the stumps were removed. The loam taken from this portion of the reservoir was used in filling the shallow places, and was covered with gravel to a depth of 6 inches, making steep slopes around the shores, so that the depth is generally not less than 6 feet at high water. The watershed, exclusive of the watershed of Lake

## MARLBOROUGH.

Williams, the present source of supply, has an area of about 3.5 square miles and contains considerable population, located chiefly at the upper end.

Water from this reservoir will be supplied to the city when required by pumping at the present pumping station on Millham Brook, near the upper end of the reservoir. By means of this pumping station water can be forced to the pumping station at Lake Williams, and either discharged into the lake or pumped again to the distributing reservoir for the supply of the city.

During the spring of 1895 46,500,000 gallons of water were pumped from Millham Brook above the storage reservoir into Lake Williams, the present source of supply. This is about a quarter of the total quantity of water consumed by the city during the year.

*Chemical Examination of Water from Lake Williams, Marlborough.*

(Parts per 100,000.)

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORATION. |                      | AMMONIA. |             |            |            | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|----------------------------|----------------------|----------|-------------|------------|------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                     | Loss on<br>Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                            |                      |          | Total.      | Dissolved. | Suspended. |           |                |           |                  |           |
|         |                     |             |            |        |                            |                      |          |             |            |            |           |                |           |                  |           |
| 95      | 1893.<br>Mar. 19    | V. slight.  | V. slight. | .15    | 4.25                       | 1.05                 | .0004    | .0172       | .0130      | .0042      | .51       | .0180          | .0000     | .3041            | 2.2       |
| 5       | Apr. 17             | Slight.     | Cons.      | .12    | 4.70                       | 2.00                 | .0006    | .0162       | .0152      | .0010      | .45       | .0150          | .0000     | .3002            | 1.7       |
| 2       | May 17              | Slight.     | Slight.    | .08    | 3.70                       | 1.40                 | .0006    | .0180       | .0162      | .0018      | .46       | .0000          | .0000     | .2528            | 1.9       |
| 1       | Oct. 23             | Slight.     | Slight.    | .10    | 3.80                       | 0.95                 | .0006    | .0190       | .0178      | .0012      | .49       | .0030          | .0000     | .2769            | 1.7       |
|         | .....               | .....       | .....      | .11    | 4.11                       | 1.35                 | .0006    | .0176       | .0156      | .0020      | .48       | .0090          | .0000     | .2835            | 1.9       |

*Averages by Years.*

|       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |     |
|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|-----|
| 1887* | - | - | .08 | 4.10 | 0.65 | .0010 | .0178 | -     | -     | .45 | .0017 | -     | -     | -   | -   |
| 1888  | - | - | .05 | 3.99 | 0.91 | .0005 | .0205 | -     | -     | .44 | .0064 | .0001 | -     | -   | -   |
| 1889  | - | - | .04 | 3.92 | 1.03 | .0007 | .0220 | .0182 | .0038 | .46 | .0064 | .0001 | -     | -   | -   |
| 1890  | - | - | .03 | 4.41 | 1.13 | .0007 | .0206 | .0165 | .0041 | .46 | .0078 | .0000 | -     | -   | 2.3 |
| 1891  | - | - | .05 | 4.12 | 1.20 | .0009 | .0197 | .0162 | .0035 | .45 | .0072 | .0001 | -     | -   | 1.8 |
| 1892† | - | - | .08 | 4.30 | 1.48 | .0008 | .0244 | .0174 | .0070 | .46 | .0115 | .0003 | -     | -   | 1.7 |
| 1893  | - | - | .05 | 3.95 | 0.88 | .0014 | .0169 | .0136 | .0033 | .40 | .0033 | .0000 | .2012 | 1.7 |     |
| 1894  | - | - | .09 | 4.20 | 1.21 | .0001 | .0154 | .0136 | .0019 | .45 | .0030 | .0000 | .2246 | 1.7 |     |
| 1895  | - | - | .11 | 4.11 | 1.35 | .0005 | .0176 | .0156 | .0020 | .48 | .0090 | .0000 | .2835 | 1.9 |     |

\* June to December.

† March and April.

o analyses of 1895: Odor of the first and last samples, faintly vegetable; of the second, being distinctly vegetable and somewhat unpleasant on heating; of the third, distinctly unappearing on heating. — The first and third samples were collected from a faucet at the station while pumping, and the other samples from the lake.

*Microscopical Examination.*

number of organisms per cubic centimeter found in each of these samples was as follows: No. 14185, 79; No. 14322, 227; No. 16424, 81.

**MARLBOROUGH.***Chemical Examination of Water from Millham Brook near its Entrance to the Millham Brook Storage Reservoir, Marlborough.*

[Parts per 100,000.]

| Number.  | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|----------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|          |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|          |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 14008    | 1895. Mar. 19       | V. slight.  | V. slight. | 0.48   | 4.00                    | 1.25              | .0026    | .0152       | .0136      | .0016      | .31       | .0280       | .0001     | .4937            | 2.1       |
| 14184    | Apr. 17             | None.       | V. slight. | 0.55   | 4.20                    | 1.90              | .0018    | .0136       | .0124      | .0012      | .36       | .0280       | .0002     | .5230            | 1.6       |
| 14323    | May 17              | V. slight.  | Slight.    | 1.10   | 5.05                    | 2.35              | .0002    | .0238       | .0232      | .0006      | .28       | .0070       | .0001     | .8176            | 1.8       |
| 15423    | Oct. 23             | V. slight.  | V. slight. | 0.90   | 5.40                    | 2.00              | .0004    | .0236       | .0220      | .0016      | .39       | .0130       | .0001     | .8541            | 1.9       |
| 15493    | Nov. 6              | None.       | Slight.    | 0.73   | 5.75                    | 2.40              | .0002    | .0190       | .0176      | .0014      | .44       | .0240       | .0001     | .7738            | 1.9       |
| 15698    | Dec. 9              | V. slight.  | V. slight. | 0.50   | 4.55                    | 1.75              | .0006    | .0140       | .0124      | .0016      | .28       | .0300       | .0000     | .4914            | 1.6       |
| Av. .... | .....               | .....       | .....      | 0.71   | 4.83                    | 1.94              | .0010    | .0182       | .0169      | .0013      | .34       | .0217       | .0001     | .6589            | 1.8       |

Odor, faintly vegetable; generally stronger on heating. — The first four samples were collected from a small reservoir, just above the Millham Brook reservoir, from which water was pumped for the supply of the city; the last two samples, from the brook just above the small reservoir.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 14008, 9; No. 14184, 8; No. 14323, 240; No. 15423, 49; No. 15493, 26; No. 15698, 3.

*Chemical Examination of Water from the North Branch of Millham Brook near its entrance to the Millham Brook Storage Reservoir, Marlborough.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 15492   | 1895.<br>Nov. 6     | Slight.     | Slight.    | 1.70   | 7.20                    | 3.95              | .0006    | .0314       | .0302      | .0012      | .54       | .0080       | .0000     | 1.9890           | 1.6       |
| 15699   | Dec. 9              | None.       | V. slight. | 1.15   | 5.15                    | 2.10              | .0004    | .0210       | .0194      | .0016      | .35       | .0120       | .0000     | 0.9243           | 1.3       |

Odor of the first sample, distinctly vegetable and mouldy; of the last, faintly vegetable.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 15492, 77; No. 15699, 6.

## MARLBOROUGH.

*Chemical Examination of Water from Millham Brook Storage Reservoir, Marlborough.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 15494   | 1895.<br>Nov. 6     | Distinct.   | Slight.   | 1.20   | 6.15                    | 3.35              | .0002    | .0392       | .0346      | .0046      | .32       | .0120       | .0002     | 1.3884           | 1.7       |
| 15700   | Dec. 8              | V. slight.  | Slight.   | 1.00   | 5.00                    | 2.20              | .0016    | .0334       | .0288      | .0048      | .26       | .0050       | .0002     | 0.8674           | 1.6       |

Odor of the first sample, distinctly vegetable; of the last, faintly vegetable. — The samples were collected from the reservoir, near the dam.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 15494, 347; No. 15700, 153.

## WATER SUPPLY OF BRANT ROCK, MARSHFIELD. — BRANT ROCK WATER COMPANY.

*Chemical Examination of Water from the Works of the Brant Rock Water Company.*

[Parts per 100,000.]

| Number, | Date of<br>Collection. | APPEARANCE. |           |        | Residue on<br>Evaporation. | AMMONIA. |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen<br>Consumed. | Hardness. | Iron. |
|---------|------------------------|-------------|-----------|--------|----------------------------|----------|-----------------|-----------|----------------|-----------|---------------------|-----------|-------|
|         |                        | Turbidity.  | Sediment. | Color. |                            | Free.    | Albu-<br>minoid |           | Nitrates.      | Nitrites. |                     |           |       |
|         |                        |             |           |        |                            |          |                 |           |                |           |                     |           |       |
| 14648   | 1895.<br>July 16       | None.       | None.     | .00    | 11.50                      | .0004    | .0024           | 3.00      | .1100          | .0000     | .0450               | 2.2       | .0000 |

Odor, none. — The sample was collected from a faucet at the pumping station.

*Microscopical Examination.*

No organisms.

## WATER SUPPLY OF MAYNARD.

In 1895 an open receiving chamber was constructed near the pumping station, into which the conduit from White Pond discharges. The chamber is 70 feet long, 40 feet wide and 17 feet deep, the side walls being built of masonry and the bottom of con-

**MAYNARD.**

crete. Water passes from the receiving chamber into the old pump well. When the water in the receiving chamber is drawn to a low level it is said that there is a considerable infiltration of ground water.

*Chemical Examination of Water from White Pond, Maynard.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. |           |
|---------|---------------------|---------------------|-------------------|--------|-------------------------|-------------------|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment.         | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |             |           | Nitrates.   | Nitrites. | Oxygen Consumed. | Hardness. |
|         |                     |                     |                   |        |                         |                   |          | Total.      | Dissolved. | Sus-pended. |           |             |           |                  |           |
| 14345   | 1895.<br>May 22     | Distinct.           | Slight.           | .02    | 2.20                    | 1.15              | .0000    | .0152       | .0136      | .0016       | .30       | .0000       | .0000     | .1444            | 0.2       |
| 15415   | Oct. 23             | Distinct,<br>green. | Slight,<br>green. | .04    | 1.95                    | 0.85              | .0004    | .0268       | .0194      | .0074       | .27       | .0050       | .0000     | .1700            | 0.2       |

Odor of the first sample, distinctly vegetable, becoming also unpleasant on heating; of the second sample, none. — The samples were collected from the pond.

*Microscopical Examination.*

No. 14345. Diatomaceæ, *Asterionella*, 72; *Cyclotella*, 80; *Diatoma*, 1; *Melosira*, 1; *Navicula*, 1; *Pleurosigma*, 1; *Synedra*, 78; *Tabellaria*, 35. Cyanophyceæ, *Merismopedia*, 2; *Microcystis*, 32. Alge, *Protococcus*, 5; *Raphidium*, 11. Infusoria, *Dinobryon*, 8; *Dinobryon cases*, 108. Miscellaneous, *Zoëglæa*, 52. Total, 487.

No. 15415. Diatomaceæ, *Asterionella*, 4; *Synedra*, 10; *Tabellaria*, 28. Cyanophyceæ, *Microcystis*, 284. Alge, *Glæocapsa*, 5; *Raphidium*, 11. Infusoria, *Peridinium*, 1. Miscellaneous, *Zoëglæa*, 7. Total, 350.

**MEDFIELD.***Chemical Examination of Water from a Spring, Medfield.*

[Parts per 100,000.]

| Number. | Date of<br>Collection. | APPEARANCE. |           |        | Residue on<br>Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN<br>As |           | Oxygen<br>Consumed. | Hardness. | Iron. |
|---------|------------------------|-------------|-----------|--------|----------------------------|----------|------------------|-----------|----------------|-----------|---------------------|-----------|-------|
|         |                        | Turbidity.  | Sediment. | Color. |                            | Free.    | Albu-<br>minoid. |           | Nitrates.      | Nitrites. |                     |           |       |
|         |                        |             |           |        |                            |          |                  |           |                |           |                     |           |       |
| 14920   | 1895.<br>Aug. 28       | None.       | None.     | .01    | 4.00                       | .0050    | .0026            | .36       | .0000          | .0000     | .0468               | 1.1       | .0050 |

Odor, none. — The sample was collected from a spring near Vine Brook, about one-third of a mile above North Street. This spring is used as a source of water supply by a large straw factory and by a portion of the village of Medfield.

*Microscopical Examination.*

No organisms.

## MEDFIELD.

## WATER SUPPLY OF MEDFIELD INSANE ASYLUM.

*Chemical Examination of Water from a Tubular Well at the Medfield Insane Asylum.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |          | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albaminoid. |           | Nitrate.    | Nitrite. |                  |           |       |
| 14533   | 1895.<br>June 24    | V. slight.  | V. slight. | .00    | 3.80                    | .0000    | .0010       | .87       | .0050       | .0000    | .0346            | 0.9       | .0070 |

Odor, none. — The sample was collected from the well.

No organisms.

*Microscopical Examination.*

## WATER SUPPLY OF MEDFORD.

In 1895 a new dam at Wright's Pond was completed, increasing the storage capacity to about 72,000,000 gallons. The area of the pond at high water is now 23 acres, and its average depth about 10 feet. None of the soil was removed from the area flowed. The area of the watershed, including the area of the pond, is about 191 acres, consisting chiefly of wood land, and containing a very small population. Water from Wright's Pond may be pumped to supply the high-service system, or may be supplied to the town by gravity by means of a connection with the main pipe from Spot Pond to the town, which passes near Wright's Pond.

In connection with the high-service system there is a standpipe 35 feet in diameter and 60 feet in height.

In addition to the supply obtained from Wright's Pond, water is pumped at times for the supply of the city from two tributaries of the brook flowing from Wright's Pond, known as the East Arm and the West Arm. The water from these sources and from Wright's Pond can be pumped into Spot Pond if desired.

Further information regarding the water supply of Medford from Spot Pond and analyses of the water of this pond may be found on pages 217 and 218 of this volume.



**MEDFORD.***Chemical Examination of Water from Wright's Pond, Medford.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 14443   | 1895.<br>June 10    | Distinct.   | Cons.     | .50    | 6.05                    | 2.25              | .0068    | .0252       | .0220      | .0032      | .58       | .0050       | .0001     | .6080            | 2.2       |
| 15666   | Dec. 3              | Slight.     | Slight.   | .50    | 5.55                    | 2.15              | .0064    | .0214       | .0194      | .0020      | .47       | .0050       | .0002     | .5850            | 2.1       |

Odor of the first sample, vegetable; of the last, aromatic, becoming vegetable on heating. — The first sample was collected from a faucet at the temporary pumping station while pumping water from the pond; the second, from Wright's Pond.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 14443, 604; No. 15666, 189.

*Chemical Examination of Water from a Brook near Wright's Pond, Medford.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                    |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|--------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.          | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                    |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 15665   | 1895.<br>Dec. 3     | Slight.     | Slight,<br>earthy. | .43    | 3.25                    | 1.15              | .0056    | .0180       | .0146      | .0014      | .45       | .0100       | .0003     | .4680            | 1.5       |

Odor, faintly vegetable. — The sample was collected from a brook entering the stream which forms the outlet of Wright's Pond from the east, and known as the east arm, just below the pond.

*Microscopical Examination.*

An insignificant number of organisms was found in this sample.

## MEDFORD.

*Chemical Examination of Water from Underdrains beneath the Sewers, Medford.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | Residue on Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-------------------|--------|-------------------------|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.         | Color. |                         | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 14684   | 1895.<br>July 23    | None.       | V. slight.        | .04    | 10.50                   | .0640    | .0050            | 2.50      | .0000       | .0007     | .0525            | 3.9       | .0220 |
| 14685   | July 23             | V. slight.  | Cons.,<br>yellow. | .04    | 347.20                  | .0960    | .0050            | 161.00    | .1350       | .0011     | .2962            | 64.5      | .0200 |

Odor of the first sample, offensive; of the second, distinctly musty. — The first sample was collected from the underdrain in Spring Street near Charles Street; the second sample was collected from an underdrain in Boston Street near the Mystic River.

*Microscopical Examination.*No. 14684. Fungi, *Crenothrix*, 1.No. 14685. Fungi, *Crenothrix*, 226. Miscellaneous, *Zooglaea*, 206. Total, 432.

## MEDWAY.

*Chemical Examination of Water from Test Wells, Medway.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.          |                    |        | Residue on Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|----------------------|--------------------|--------|-------------------------|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.           | Sediment.          | Color. |                         | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 14719   | 1895.<br>July 26    | Slight,<br>clayey.   | Cons.,<br>sandy.   | .05    | 5.75                    | .0052    | .0042            | 0.58      | .0030       | .0000     | .1155            | 2.2       | .0175 |
| 14844   | Aug. 15             | V. slight.           | V. slight.         | .04    | 5.20                    | .0048    | .0042            | 0.60      | .0000       | .0000     | .1716            | 2.2       | .0120 |
| 15050   | Sept. 7             | None.                | None.              | .02    | 6.30                    | .0020    | .0024            | 0.67      | .0030       | .0000     | .1544            | 2.5       | .0100 |
| 14720   | July 26             | Distinct,<br>clayey. | Heavy,<br>sandy.   | .03    | 13.15                   | .0020    | .0010            | 1.44      | .3150       | .0003     | .0385            | 4.2       | .0150 |
| 14845   | Aug. 15             | Slight.              | Cons.,<br>sandy.   | .04    | 12.50                   | .0000    | .0018            | 1.46      | .1860       | .0000     | .0546            | 3.9       | .0550 |
| 15051   | Sept. 7             | None.                | None.              | .00    | 15.00                   | .0000    | .0000            | 1.65      | .3333       | .0000     | .0312            | 4.2       | .0100 |
| 15636   | Nov. 29             | None.                | None.              | .00    | 6.20                    | .0000    | .0022            | 0.54      | .0000       | .0000     | .0897            | 1.4       | .0630 |
| 15637   | Nov. 29             | Slight.              | Slight,<br>earthy. | .03    | 7.70                    | .0000    | .0004            | 0.64      | .1000       | .0000     | .0156            | 3.1       | .0050 |

Odor, none. — The samples were collected from tubular test wells near the Charles River, below the village of Medway, located as follows: the first three samples, from a well between Village Street and Charles River, just above Walker Street; the next three, from a well about 20 feet west of Village Street and 100 feet north of Walker Street; No. 15636, near the factory of Ray & Wilson, at the corner of Village and Walker streets; the last, from a well 100 feet west of Village Street and about 200 feet north of Walker Street. The samples were collected during an investigation of possible sources of water supply for the town of Medway.

*Microscopical Examination.*

No organisms.

**MEDWAY.***Chemical Examination of Water from a Spring, Medway.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 14718   | 1895.<br>July 26    | None.       | V. slight. | .03    | 8.95                    | .0000    | .0026       | 1.13      | .1200       | .0003     | .0770            | 3.1       | .0040 |

Odor, none. — The sample was collected from a roadside spring near Village Street, about 150 feet north of Walker Street.

*Microscopical Examination.*

An insignificant number of organisms was found in this sample.

*Chemical Examination of Water from the Charles River at Medway.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                  |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.        | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                  |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 14717   | 1895.<br>July 26    | Slight.     | Slight,<br>dark. | 1.25   | 6.75                    | 2.15              | .0050    | .0400       | .0320      | .0080      | .57       | .0050       | .0002     | 1.1742           | 1.8       |

Odor, distinctly vegetable and mouldy. — The sample was collected from the river a short distance below the village of Medway, at Ray & Wilson's dam, just above Walker Street.

*Microscopical Examination.*

Diatomaceæ, *Synedra*, 2; *Tabellaria*, 1. Algae, *Glaucocapsa*, 32; *Pandorina*, 3; *Protococcus*, 9; *Scenedesmus*, 1; *Stauronegia*, 1. Fungi, *Orenothrix*, 460. Total, 509.

**WATER SUPPLY OF MELROSE.**

For information regarding the water supply of Melrose from Spot Pond and for analyses of water from the pond see pages 217 and 218.

The results of analyses of samples of water from the auxiliary ground-water supply introduced in 1894 are given in the following table: —

## MELROSE.

*Chemical Examination of Water from Tubular Wells in the Valley of Spot Pond Brook, near Wyoming Avenue, used as an Additional Source of Water Supply for Melrose.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         |                     |             |            |        |                         |          |                  |           |             |           |                  |           |       |
| 1895.   |                     |             |            |        |                         |          |                  |           |             |           |                  |           |       |
| 13957   | Mar. 11             | V. slight.  | Slight.    | .05    | 10.30                   | .0016    | .0054            | 1.17      | .0520       | .0001     | .1478            | 4.3       | .0050 |
| 14473   | June 14             | V. slight.  | V. slight. | .08    | 13.80                   | .0000    | .0026            | 1.49      | .0450       | .0001     | .0741            | 6.4       | .0190 |
| 14557   | July 1              | None.       | None.      | .10    | 13.30                   | .0000    | .0044            | 1.26      | .0830       | .0000     | .1556            | 5.9       | .0100 |
| 15165   | Sept. 13            | None.       | None.      | .03    | 15.80                   | .0000    | .0022            | 1.68      | .0780       | .0002     | .0039            | 8.4       | .0030 |
| 15276   | Sept. 30            | None.       | None.      | .03    | 10.60                   | .0004    | .0006            | 1.40      | .3900       | .0002     | .0094            | 4.2       | .0200 |
| 15707   | Dec. 9              | None.       | None.      | .04    | 13.80                   | .0004    | .0034            | 1.50      | .0730       | .0005     | .0663            | 7.3       | .0080 |
| Av.     | .....               | .....       | .....      | .06    | 12.88                   | .0004    | .0034            | 1.39      | .0974       | .0002     | .0901            | 6.0       | .0107 |

Odor, none. — No. 15276 was collected from a group of new wells; the other samples, from faucets in Melrose supplied from the tubular wells.

*Microscopical Examination.*

No. 13957. Fungi, *Oreothrix*, 7.

No. 15276. Fungi, *Molds*, 1.

No organisms were found in the other samples.

## WATER SUPPLY OF METHUEN.

*Chemical Examination of Water from the Tubular Wells of the Methuen Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                |        | Residue on Evaporation | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|----------------|--------|------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.      | Color. |                        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 1895.   |                     |             |                |        |                        |          |             |           |             |           |                  |           |       |
| 13706   | Jan. 23             | None.       | V. slight.     | .01    | 7.60                   | .0000    | .0048       | .26       | .0050       | .0000     | .0632            | 3.1       | .0100 |
| 13801   | Feb. 11             | Slight.     | Cons., clayey. | .05    | 9.70                   | .0000    | .0024       | .26       | .0070       | .0000     | .0800            | 3.2       | .0100 |
| 13966   | Mar. 11             | None.       | Slight.        | .05    | 7.50                   | .0000    | .0040       | .28       | .0070       | .0000     | .0739            | 3.2       | .0050 |
| 14112   | Apr. 8              | Distinct.   | Slight.        | .02    | 7.50                   | .0000    | .0012       | .28       | .0070       | .0000     | .0616            | 3.1       | .0090 |
| 14249   | May 6               | None.       | None.          | .03    | 7.70                   | .0000    | .0018       | .31       | .0050       | .0001     | .0539            | 3.8       | .0100 |
| 14440   | June 10             | V. slight.  | None.          | .07    | 7.70                   | .0000    | .0020       | .22       | .0070       | .0000     | .0859            | 3.5       | .0150 |
| 14623   | July 15             | None.       | V. slight.     | .07    | 6.80                   | .0000    | .0024       | .24       | .0100       | .0000     | .1248            | 3.1       | .0120 |
| 14808   | Aug. 12             | None.       | V. slight.     | .04    | 6.80                   | .0000    | .0028       | .23       | .0080       | .0000     | .1326            | 3.2       | .0180 |
| 15111   | Sept. 9             | Slight.     | Slight.        | .15    | 7.10                   | .0006    | .0038       | .27       | .0050       | .0002     | .1560            | 3.1       | .0280 |
| 15347   | Oct. 9              | None.       | None.          | .03    | 6.90                   | .0000    | .0044       | .30       | .0030       | .0000     | .0780            | 3.0       | .0050 |
| 15522   | Nov. 12             | None.       | None.          | .10    | 6.80                   | .0000    | .0038       | .26       | .0080       | .0000     | .0796            | 2.9       | .0300 |
| 15705   | Dec. 10             | None.       | None.          | .05    | 7.20                   | .0000    | .0026       | .26       | .0030       | .0000     | .0780            | 2.7       | .0080 |
| Av.     | .....               | .....       | .....          | .06    | 7.44                   | .0001    | .0030       | .26       | .0062       | .0000     | .0892            | 3.2       | .0133 |

Odor, faint or none. — Nos. 13706, 13966, 14249, 14440, 15111, 15522 and 15705 were collected from a faucet at the pumping station; the remaining samples, from a faucet near the pumping station.

*Microscopical Examination.*

An insignificant number of organisms was found in these samples.

**METHUEN.***Chemical Examination of Water from the Covered Reservoir of the Methuen Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |              |        | Residue on Evaporation. | AMMONIA. |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|--------------|--------|-------------------------|----------|------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment.    | Color. |                         | Free.    | Albominal. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1895.</b>        |                  |              |        |                         |          |            |           |             |           |                  |           |       |
| 13707   | Jan. 23             | None.            | None.        | .02    | 7.00                    | .0000    | .0024      | .23       | .0030       | .0000     | .0513            | 3.1       | .0120 |
| 13802   | Feb. 12             | V. slight.       | V. slight.   | .10    | 8.40                    | .0000    | .0044      | .30       | .0030       | .0000     | .0560            | 3.4       | .0100 |
| 13967   | Mar. 12             | None.            | Cons. white. | .08    | 8.70                    | .0004    | .0040      | .26       | .0050       | .0000     | .0847            | 3.5       | .0070 |
| 14113   | Apr. 8              | V. slight.       | V. slight.   | .02    | 7.60                    | .0000    | .0010      | .27       | .0050       | .0000     | .0616            | 3.1       | .0110 |
| 14250   | May 6               | V. slight.       | V. slight.   | .04    | 7.90                    | .0000    | .0018      | .27       | .0070       | .0000     | .0500            | 3.8       | .0100 |
| 14441   | June 10             | None.            | None.        | .07    | 7.20                    | .0000    | .0022      | .24       | .0050       | .0000     | .0760            | 3.2       | .0180 |
| 14624   | July 15             | None.            | V. slight.   | .08    | 7.50                    | .0000    | .0028      | .24       | .0070       | .0000     | .0975            | 2.9       | .0080 |
| 14809   | Aug. 12             | None.            | V. slight.   | .04    | 7.70                    | .0004    | .0026      | .26       | .0040       | .0001     | .0936            | 4.9       | .0120 |
| 15112   | Sept. 9             | None.            | None.        | .05    | 7.20                    | .0000    | .0022      | .26       | .0050       | .0000     | .1443            | 3.1       | .0070 |
| 15348   | Oct. 9              | Distinct, milky. | V. slight.   | .20    | 7.20                    | .0000    | .0028      | .29       | .0070       | .0000     | .1092            | 2.7       | .0400 |
| 15523   | Nov. 11             | None.            | None.        | .08    | 7.40                    | .0000    | .0034      | .28       | .0070       | .0000     | .0608            | 2.9       | .0140 |
| 15706   | Dec. 10             | Slight.          | V. slight.   | .12    | 9.70                    | .0004    | .0036      | .22       | .0030       | .0001     | .0952            | 2.6       | .0280 |
| Av.     | .....               | .....            | .....        | .07    | 7.87                    | .0001    | .0025      | .26       | .0051       | .0000     | .0817            | 3.3       | .0147 |

Odor, none, except in March, when it was faintly unpleasant, and in May, when it was very faintly vegetable. — Nos. 14441, 15112, 15523 and 15706 were collected from the reservoir, and the others from a faucet near the reservoir.

*Microscopical Examination.*

An insignificant number of organisms was found in these samples.

*Chemical Examination of Water from a Faucet in Methuen supplied from the Methuen Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |           |        | Residue on Evaporation. | AMMONIA. |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|-----------|--------|-------------------------|----------|------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment. | Color. |                         | Free.    | Albominal. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1895.</b>        |                  |           |        |                         |          |            |           |             |           |                  |           |       |
| 14859   | Aug. 19             | Distinct, milky. | Slight.   | 1.30   | 8.00                    | .0000    | .0032      | .22       | .0030       | .0000     | .1248            | 3.2       | .4000 |

Odor, decidedly tarry and unpleasant. — The faucet from which the sample was collected is near the end of a 6-inch pipe.

*Microscopical Examination.*

An insignificant number of organisms was found in this sample.

**MIDDLEBOROUGH.**  
**WATER SUPPLY OF MIDDLEBOROUGH FIRE DISTRICT — MIDDLEBOROUGH.**

*Chemical Examination of Water from the Well of the Middleborough Fire District.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 1895.   |                     |             |            |        |                         |          |             |           |             |           |                  |           |       |
| 13612   | Jan. 7              | None.       | None.      | .03    | 7.30                    | .0000    | .0012       | .82       | .1300       | .0000     | .0429            | 2.9       | .0070 |
| 13773   | Feb. 6              | None.       | None.      | .00    | 7.40                    | .0006    | .0028       | .81       | .1050       | .0000     | .0316            | 3.0       | .0070 |
| 13939   | Mar. 6              | None.       | None.      | .00    | 7.70                    | .0000    | .0008       | .78       | .0980       | .0000     | .0462            | 2.5       | .0050 |
| 14093   | April 3             | None.       | None.      | .00    | 7.10                    | .0000    | .0014       | .78       | .1000       | .0000     | .0462            | 3.1       | .0060 |
| 14258   | May 7               | None.       | None.      | .05    | 7.70                    | .0000    | .0024       | .85       | .1100       | .0000     | .0385            | 2.5       | .0090 |
| 14421   | June 5              | None.       | None.      | .04    | 7.40                    | .0000    | .0030       | .75       | .0320       | .0000     | .1140            | 2.3       | .0160 |
| 14603   | July 10             | None.       | None.      | .08    | 5.90                    | .0000    | .0054       | .68       | .0280       | .0001     | .1343            | 2.3       | .0100 |
| 14784   | Aug. 7              | None.       | V. slight. | .13    | 6.10                    | .0000    | .0040       | .68       | .0500       | .0001     | .1404            | 3.0       | .0420 |
| 14979   | Sept. 4             | None.       | None.      | .15    | 6.50                    | .0000    | .0046       | .65       | .0300       | .0001     | .1347            | 2.2       | .0420 |
| 15321   | Oct. 7              | None.       | V. slight. | .12    | 5.80                    | .0002    | .0028       | .66       | .0280       | .0000     | .1186            | 2.3       | .0420 |
| 15485   | Nov. 6              | None.       | None.      | .08    | 5.60                    | .0000    | .0022       | .70       | .0520       | .0000     | .0819            | 2.1       | .0230 |
| 15679   | Dec. 4              | None.       | V. slight. | .07    | 6.40                    | .0000    | .0032       | .73       | .0620       | .0000     | .0741            | 2.6       | .0160 |
| Av.     | .....               | .....       | .....      | .06    | 6.74                    | .0001    | .0028       | .74       | .0687       | .0000     | .0836            | 2.6       | .0187 |

*Averages by Years.*

|   |       |   |   |     |      |       |       |     |       |       |       |     |       |
|---|-------|---|---|-----|------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1887* | - | - | .00 | 8.89 | .0004 | .0019 | .96 | .1519 | -     | -     | -   | -     |
| - | 1888  | - | - | .00 | 8.67 | .0001 | .0025 | .96 | .1494 | .0001 | -     | -   | -     |
| - | 1889† | - | - | .00 | 8.77 | .0002 | .0024 | .98 | .1770 | .0001 | -     | -   | -     |
| - | 1893‡ | - | - | .05 | 6.53 | .0006 | .0024 | .73 | .0775 | .0001 | .0840 | 2.6 | .0070 |
| - | 1894* | - | - | .09 | 6.16 | .0004 | .0032 | .69 | .0572 | .0001 | .0804 | 2.3 | .0287 |
| - | 1895  | - | - | .06 | 6.74 | .0001 | .0028 | .74 | .0687 | .0000 | .0836 | 2.6 | .0187 |

\* June to December.

† January to May.

‡ April and September.

NOTE to analyses of 1895: Odor, none, except in July, when it was very faintly vegetable and unpleasant. The odor of the October sample was faintly vegetable on heating. — The samples were collected from a faucet at the pumping station while pumping.

*Microscopical Examination.*

*Crenothrix* was the only organism found in any of the samples, the largest number in any one sample being 242 in November.

**WATER SUPPLY OF MILFORD. — MILFORD WATER COMPANY.**

In 1895 a filter was constructed near the pumping station, for the filtration of that portion of the water supply which is drawn directly from the Charles River. The filter has an area of about a quarter of an acre and consists of five feet in depth of sand taken from a bank in the immediate vicinity. Before being applied to the filter the water from the river is passed through a small settling basin. During the summer of 1895 it is said that about 400,000 gallons of water were filtered daily, and that the filter was cleaned about once in six weeks when running at this rate.

**MILLBURY.****WATER SUPPLY OF MILLBURY. — MILLBURY WATER COMPANY.**

Population in 1895, 5,222. The works are owned by the Millbury Water Company, and water was first introduced Nov. 16, 1895. The source of supply is a large well located near the Millbury branch of the Boston & Albany Railroad, about half a mile north of the village.

The well is built of stone masonry, and is 20 feet in diameter and 40 feet deep. Water is pumped from the well into the mains, and to a distributing reservoir about two miles distant.

The distributing reservoir is circular in shape, 135 feet in diameter, 15 feet deep, and has a capacity of about 1,500,000 gallons. It is built of stone, lined with cement, and is covered with a wooden roof.

The advice of the State Board of Health to the Millbury Water Company, with reference to the use of water from this source as a public water supply, may be found on page 35 of the annual report for 1892.

**WATER SUPPLY OF MILLIS.**

The town of Millis purchased the works of the Millis Water Company in 1894 and took possession of them on Jan. 1, 1895.

*Chemical Examination of Water from the Aqua Rex Spring, Millis.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |              | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|--------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Frees.   | Albu-minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 15426   | 1895.<br>Oct. 24    | None.       | None.     | .00    | 5.90                    | .0000    | .0026        | .42       | .1050       | .0000     | .0328            | 2.1       | .0010 |

Odor, none. — The sample was collected from the reservoir.

*Microscopical Examination.*

Fungi, Molds, 1.

**WATER SUPPLY OF MILTON. — MILTON WATER COMPANY.**

The water supplied by this company to the town is purchased from the Hyde Park Water Company. Analyses of the water may be found on pages 183-186.

## MONSON.

## WATER SUPPLY OF MONSON.

Population in 1895, 3,746. The works are owned by the town and were completed in the spring of 1895. The source of supply is a large well in the valley of Ingalls Brook near its junction with Conant Brook, about  $2\frac{1}{2}$  miles from the village, in the westerly part of the town. The well is 73 feet in diameter at the top and 23 feet deep, and is lined with stone laid without mortar. The surface of the ground in the vicinity of the well is over 300 feet above the level of the village, and water flows directly from the well into the distributing system, by gravity.

The advice of the State Board of Health to the town of Monson relative to the use of water from this source may be found on pages 29 and 30 of the annual report for 1894.

## MONTAGUE.

The advice of the State Board of Health to a water supply committee of the village of Miller's Falls, relative to the introduction of a public water supply for the village of Miller's Falls in the towns of Montague and Erving and the village known as Lake Pleasant in Montague, by extending the pipes of the Turner's Falls water works, may be found on page 37 of this report.

An analysis of a sample of water from Green Pond, Montague, collected in connection with this investigation, is given below.

*Chemical Examination of Water from Green Pond, Montague.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13569   | 1895.<br>Feb. 20    | V. slight.  | Slight.   | .03    | 1.20                    | 0.70              | .0230    | .0226       | .0204      | .0022      | .14       | .0000       | .0000     | .1755            | 1.9       |

Odor, distinctly vegetable. — The sample was collected from the pond, near the middle.

*Microscopical Examination.*

Diatomaceæ, *Asterionella*, 5.

The advice of the State Board of Health to W. H. Nims and others of the village of Montague Center, relative to the use of the



**MONTAGUE.**

water of certain springs as a source of public water supply for the village, may be found on pages 37 and 38 of this volume. An analysis of a sample of water collected from a brook flowing from the springs is given below.

*Chemical Examination of Water from a Brook near Montague Center.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 13823   | 1895.<br>Feb. 14    | None.       | Slight.   | .02    | 3.70                    | .0000    | .0016       | .10       | .0200       | .0000     | .0360            | 1.8       | .0000 |

Odor, none. — The sample was collected from a brook flowing from springs just above the Leverett Road, a short distance south of the village of Montague Center.

*Microscopical Examination.*

An insignificant number of organisms was found in this sample.

Near the end of the year an application was received from a water supply committee of the village of Miller's Falls in Montague, for advice relative to the use of Osgood Brook in Montague and Wendell as a source of public water supply. Analyses of samples of water collected from this source are given below.

*Chemical Examination of Water from Ruggles Pond and Osgood Brook in Wendell and Montague.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 15690   | 1895.<br>Dec. 8     | None.       | V. slight. | .88    | 3.00                    | 1.30              | .0006    | .0102       | .0092      | .0010      | .08       | .0020       | .0000     | .7644            | 0.5       |
| 15780   | Dec. 19             | V. slight.  | V. slight. | .70    | 2.90                    | 1.20              | .0004    | .0118       | .0102      | .0016      | .06       | .0030       | .0000     | .6391            | 0.2       |
| 15689   | Dec. 8              | None.       | Slight.    | .85    | 2.75                    | 1.25              | .0004    | .0092       | .0086      | .0006      | .08       | .0000       | .0000     | .7566            | 0.3       |
| 15779   | Dec. 19             | None.       | V. slight. | .37    | 2.85                    | 0.80              | .0004    | .0084       | .0064      | .0020      | .07       | .0000       | .0000     | .4081            | 0.2       |

Odor of the first sample, distinctly mouldy; of the second, distinctly vegetable and mouldy; of the third, none, becoming faintly vegetable on heating; of the last sample, faintly vegetable. — The first two samples were collected from Ruggles Pond at its outlet; the last two, from Osgood Brook at Lyon's Mill, a little over a mile below Ruggles Pond.

*Microscopical Examination.*

An insignificant number of organisms was found in these samples.

MONTAGUE.

## WATER SUPPLY OF TURNER'S FALLS FIRE DISTRICT—MONTAGUE.

*Chemical Examination of Water from Lake Pleasant, Montague.*

[Parts per 100,000.]

| Number.  | Date of Collection. | APPEARANCE. |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|----------|---------------------|-------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|-----------|
|          |                     | Turbidity.  | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |             |           | Nitrates.   | Nitrites. |                  |           |
|          |                     |             |                |        |                         |                   |          | Total.      | Dissolved. | Sus-pended. |           |             |           |                  |           |
|          | <b>1895.</b>        |             |                |        |                         |                   |          |             |            |             |           |             |           |                  |           |
| 13592    | Jan. 2              | Slight.     | Slight.        | .06    | 2.25                    | 0.80              | .0044    | .0088       | .0078      | .0010       | .12       | .0020       | .0000     | .0924            | 0.8       |
| 13770    | Feb. 5              | None.       | V. slight.     | .08    | 2.35                    | 0.75              | .0082    | .0096       | .0080      | .0016       | .10       | .0090       | .0000     | .1145            | 0.5       |
| 13941    | Mar. 5              | None.       | V. slight.     | .01    | 2.15                    | 0.45              | .0032    | .0090       | .0074      | .0016       | .12       | .0070       | .0000     | .1039            | 0.5       |
| 14085    | Apr. 2              | None.       | V. slight.     | .02    | 2.55                    | 0.75              | .0000    | .0072       | .0054      | .0018       | .10       | .0080       | .0000     | .0816            | 0.8       |
| 14586    | July 8              | Slight.     | Slight, white. | .04    | 2.30                    | 0.50              | .0000    | .0110       | .0104      | .0006       | .15       | .0030       | .0000     | .1185            | 0.5       |
| 14812    | Aug. 12             | None.       | V. slight.     | .02    | 2.35                    | 0.75              | .0000    | .0070       | .0054      | .0016       | .15       | .0030       | .0000     | .1560            | 0.8       |
| 15541    | Nov. 13             | V. slight.  | V. slight.     | .12    | 2.30                    | 1.05              | .0006    | .0140       | .0086      | .0074       | .15       | .0070       | .0000     | .1248            | 0.3       |
| Av. .... |                     |             |                | .05    | 2.32                    | 0.72              | .0023    | .0095       | .0073      | .0022       | .13       | .0056       | .0000     | .1131            | 0.6       |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | .03 | 2.74 | 0.81 | .0018 | .0116 | -     | -     | .10 | .0007 | -     | -     | -   |
| - | 1888  | - | - | .00 | 2.33 | 0.49 | .0027 | .0071 | -     | -     | .09 | .0085 | .0000 | -     | -   |
| - | 1889† | - | - | .01 | 2.19 | 0.40 | .0008 | .0063 | .0052 | .0011 | .09 | .0088 | .0000 | -     | -   |
| - | 1893  | - | - | .04 | 2.28 | 0.68 | .0023 | .0115 | .0083 | .0032 | .12 | .0045 | .0000 | .1137 | 0.6 |
| - | 1894  | - | - | .04 | 2.13 | 0.68 | .0022 | .0097 | .0076 | .0021 | .12 | .0025 | .0000 | .1071 | 0.4 |
| - | 1895  | - | - | .05 | 2.32 | 0.72 | .0023 | .0095 | .0073 | .0022 | .13 | .0056 | .0000 | .1131 | 0.6 |

\* June to December.

† January to June.

NOTE to analyses of 1895: Odor in January, distinctly vegetable; in February, very faintly vegetable, becoming stronger and also unpleasant on heating; in July, decidedly unpleasant; no odor was detected in the remaining samples. — The samples were collected from faucets in the village.

*Microscopical Examination.*

The average number of organisms per cubic centimeter found in these samples was 20.

## WATER SUPPLY OF NAHANT.

(See *Swampscott*.)

## NANTUCKET.

## WATER SUPPLY OF NANTUCKET. — WANNACOMET WATER COMPANY.

*Chemical Examination of Water from Wannacomet Pond, Nantucket.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.   |                     |             |            |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 13603   | Jan. 3              | V. slight.  | Slight.    | .05    | 6.60                    | 1.60              | .0002    | .0270       | .0238      | .0032      | 2.26      | .0000       | .0000     | .1155            | 1.9       |
| 13851   | Feb. 6              | Slight.     | Slight.    | .12    | 6.30                    | 1.05              | .0014    | .0090       | .0068      | .0022      | 2.13      | .0030       | .0000     | .0858            | 1.4       |
| 13940   | Mar. 6              | V. slight.  | V. slight. | .01    | 6.55                    | 1.10              | .0008    | .0120       | .0092      | .0028      | 1.90      | .0030       | .0000     | .1016            | 1.6       |
| 14096   | Apr. 2              | V. slight.  | V. slight. | .02    | 6.40                    | 1.90              | .0006    | .0096       | .0090      | .0006      | 2.12      | .0020       | .0000     | .1193            | 1.9       |
| 14257   | May 6               | V. slight.  | Slight.    | .05    | 6.45                    | 1.65              | .0006    | .0096       | .0080      | .0016      | 2.00      | .0000       | .0000     | .0808            | 1.4       |
| 14423   | June 4              | Distinct.   | Slight.    | .02    | 6.20                    | 1.25              | .0014    | .0172       | .0142      | .0030      | 2.00      | .0030       | .0000     | .1315            | 1.6       |
| 14600   | July 9              | Distinct.   | Slight.    | .03    | 6.65                    | 1.90              | .0012    | .0138       | .0108      | .0030      | 2.30      | .0030       | .0000     | .1580            | 1.7       |
|         |                     |             | rusty.     |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 14714   | July 24             | Distinct.   | Slight.    | .07    | 6.25                    | 1.85              | .0008    | .0158       | .0122      | .0036      | 2.80      | .0030       | .0000     | .1925            | 1.9       |
| 14778   | Aug. 6              | Slight.     | Slight.    | .07    | 6.45                    | 1.75              | .0000    | .0156       | .0114      | .0042      | 2.00      | .0080       | .0000     | .1716            | 2.2       |
| 14901   | Aug. 21             | Slight.     | Slight.    | .08    | 6.00                    | 1.60              | .0010    | .0158       | .0134      | .0024      | 2.06      | .0000       | .0000     | .1950            | 1.5       |
|         |                     |             | yellow.    |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 14971   | Sept. 3             | Slight.     | Slight.    | .15    | 6.25                    | 1.25              | .0000    | .0182       | .0160      | .0022      | 2.35      | .0000       | .0001     | .2887            | 1.4       |
|         |                     |             | milky.     |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 15219   | Sept. 18            | V. slight.  | V. slight. | .15    | 6.70                    | 1.25              | .0000    | .0150       | .0126      | .0024      | 2.20      | .0000       | .0000     | .1521            | 1.6       |
|         |                     |             | milky.     |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 15324   | Oct. 7              | V. slight.  | V. slight. | .05    | 6.45                    | 1.70              | .0008    | .0158       | .0128      | .0030      | 2.40      | .0030       | .0000     | .1466            | 1.7       |
| 15411   | Oct. 21             | V. slight.  | V. slight. | .08    | 6.35                    | 1.90              | .0012    | .0130       | .0108      | .0022      | 2.05      | .0070       | .0000     | .1420            | 1.7       |
| 15484   | Nov. 5              | Slight.     | Slight.    | .10    | 6.55                    | 1.95              | .0016    | .0136       | .0104      | .0032      | 2.10      | .0030       | .0000     | .2012            | 1.4       |
| 15676   | Dec. 3              | Slight.     | V. slight. | .08    | 6.05                    | 1.85              | .0000    | .0154       | .0108      | .0046      | 2.16      | .0030       | .0000     | .1287            | 1.4       |
|         |                     |             | green.     |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| Av*     | .....               | .....       | .....      | .06    | 6.41                    | 1.57              | .0008    | .0146       | .0119      | .0027      | 2.14      | .0024       | .0000     | .1406            | 1.6       |

*Averages by Years.*

|   |        |   |   |     |      |      |       |       |       |       |      |       |       |       |     |
|---|--------|---|---|-----|------|------|-------|-------|-------|-------|------|-------|-------|-------|-----|
| - | 1887†  | - | - | .08 | 6.72 | 1.20 | .0002 | .0175 | -     | -     | 2.20 | .0020 | -     | -     | -   |
| - | 1888†  | - | - | .05 | 5.98 | 0.98 | .0002 | .0153 | -     | -     | 2.11 | .0048 | .0002 | -     | -   |
| - | 1889§  | - | - | .10 | -    | -    | .0031 | .0416 | .0269 | .0147 | 1.99 | .0055 | .0001 | -     | -   |
| - | 1890   | - | - | .00 | -    | -    | .0006 | .0188 | .0127 | .0061 | 1.95 | .0025 | .0000 | -     | -   |
| - | 1891†  | - | - | .22 | 7.54 | 2.33 | .0112 | .0588 | .0317 | .0271 | 1.86 | .0076 | .0001 | -     | 1.4 |
| - | 1892** | - | - | .03 | 6.84 | 1.68 | .0004 | .0136 | .0111 | .0025 | 2.22 | .0033 | .0000 | -     | 1.6 |
| - | 1893†  | - | - | .22 | 7.00 | 2.02 | .0013 | .0499 | .0208 | .0261 | 2.08 | .0025 | .0000 | .2167 | 1.6 |
| - | 1894†† | - | - | .05 | 6.74 | 1.65 | .0015 | .0131 | .0108 | .0023 | 2.30 | .0000 | .0000 | .1227 | 1.6 |
| - | 1895   | - | - | .06 | 6.41 | 1.57 | .0008 | .0146 | .0119 | .0027 | 2.14 | .0024 | .0000 | .1406 | 1.6 |

\* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

† July to November.

‡ February to May.

§ September to November.

|| March and April.

†† August to December.

\*\* May to October.

†† June to December.

NOTE to analyses of 1895: Odor, generally faintly vegetable, sometimes stronger and also unpleasant; rarely none. — The samples were collected as follows: Nos. 13603, 13940, 14257, 14423, 14600, 14714, 15324 and 15484, from the pond; Nos. 13851, 14096 and 15219, from the distributing tank; Nos. 14778 and 14971, from the main while pumping; Nos. 14901 and 15411, from a faucet in the pumping station; No. 15676, from the pump well.

## NANTUCKET.

*Microscopical Examination of Water from Wannacomet Pond, Nantucket.*

[Number of organisms per cubic centimeter.]

|                                    | 1895. |       |       |       |       |       |       |       |
|------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                    | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | July. |
| Day of examination, . . .          | 5     | 20    | 8     | 6     | 8     | 7     | 11    | 27    |
| Number of sample, . . .            | 13903 | 13851 | 13940 | 14096 | 14257 | 14423 | 14600 | 14714 |
| <b>PLANTS.</b>                     |       |       |       |       |       |       |       |       |
| <b>Diatomaceæ, . . .</b>           | 200   | 64    | 180   | 35    | 54    | 49    | 3     | 7     |
| <i>Cyclotella</i> , . . .          | 0     | 0     | 0     | 1     | 0     | 3     | 0     | 0     |
| <i>Navicula</i> , . . .            | 0     | 0     | 0     | 0     | 2     | 2     | 2     | 0     |
| <i>Synedra</i> , . . .             | 200   | 64    | 180   | 34    | 52    | 44    | 1     | 2     |
| <i>Tabellaria</i> , . . .          | 0     | 0     | 0     | 0     | 0     | pr.   | 0     | 5     |
| <b>Cyanophyceæ, Anabaena, .</b>    | 0     | 0     | 0     | 0     | 0     | 0     | 15    | 59    |
| <b>Algae, . . .</b>                | 0     | 0     | 0     | 0     | 2     | 2     | 8     | 0     |
| <i>Chlorococcus</i> , . . .        | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| <i>Protooccus</i> , . . .          | 0     | 0     | 0     | 0     | 2     | 2     | 6     | 0     |
| <i>Scenedesmus</i> , . . .         | 0     | 0     | 0     | 0     | 0     | pr.   | pr.   | 0     |
| <i>Zoëspores</i> , . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| <b>Fungi, Orenothrix, . . .</b>    | 0     | 3     | 0     | 0     | pr.   | 3     | 0     | 0     |
| <b>ANIMALS.</b>                    |       |       |       |       |       |       |       |       |
| <b>Infusoria, . . .</b>            | 123   | pr.   | 77    | 76    | 468   | 215   | 150   | 0     |
| <i>Oeratum</i> , . . .             | 0     | 0     | 0     | 0     | 0     | 5     | 0     | 0     |
| <i>Dinobryon</i> , . . .           | 0     | 0     | 48    | 32    | 0     | 62    | 150   | 0     |
| <i>Dinobryon cases</i> , . . .     | 123   | 0     | 28    | 44    | 464   | 148   | 0     | 0     |
| <i>Peridinium</i> , . . .          | 1     | 0     | 1     | 0     | 4     | 0     | pr.   | 0     |
| <i>Trachelomonas</i> , . . .       | pr.   | pr.   | 0     | 0     | 0     | 0     | 0     | 0     |
| <b>Vermes, . . .</b>               | 0     | 0     | 1     | 1     | 3     | pr.   | 0     | 0     |
| <i>Anurea</i> , . . .              | 0     | 0     | 0     | 0     | 3     | pr.   | 0     | 0     |
| <i>Polyarthra</i> , . . .          | 0     | 0     | 1     | 1     | pr.   | 0     | 0     | 0     |
| <b>Miscellaneous, Zoöglææ, . .</b> | 0     | 8     | 0     | 0     | 0     | 0     | 0     | 0     |
| <b>TOTAL, . . .</b>                | 323   | 75    | 258   | 112   | 527   | 269   | 174   | 66    |

## NANTUCKET.

*Microscopical Examination of Water from Wannacomet Pond, Nantucket —*  
Concluded.

[Number of organisms per cubic centimeter.]

|                             | 1898.     |            |           |           |           |            |            |              |
|-----------------------------|-----------|------------|-----------|-----------|-----------|------------|------------|--------------|
|                             | Aug.      | Aug.       | Sept.     | Sept.     | Oct.      | Oct.       | Nov.       | Dec.         |
| Day of examination, . . .   | 8         | 23         | 6         | 21        | 9         | 24         | 7          | 5            |
| Number of sample, . . .     | 14778     | 14901      | 14971     | 15219     | 15324     | 15411      | 15484      | 15676        |
| <b>PLANTS.</b>              |           |            |           |           |           |            |            |              |
| Diatomaceæ, . . .           | 11        | 23         | 8         | 4         | 1         | 1          | 2          | 185          |
| Cyclotella, . . .           | 0         | 14         | 0         | 0         | 0         | 0          | 0          | 0            |
| Navicula, . . .             | 1         | 0          | 0         | 0         | 1         | 0          | 0          | 1            |
| Synedra, . . .              | 6         | 9          | 6         | 3         | 0         | 1          | 2          | 184          |
| Tabellaria, . . .           | 4         | 0          | 0         | 1         | 0         | 0          | 0          | 0            |
| Cyanophyceæ, Anabaena, .    | 0         | 0          | 0         | 0         | 3         | 0          | 0          | 0            |
| Algae, . . .                | 0         | 59         | 0         | 0         | 0         | 0          | 0          | 11           |
| Chlorococcus, . . .         | 0         | 34         | 0         | 0         | 0         | 0          | 0          | 0            |
| Protooccus, . . .           | 0         | 1          | 0         | 0         | 0         | 0          | 0          | 11           |
| Scenedesmus, . . .          | 0         | 7          | 0         | 0         | 0         | 0          | 0          | 0            |
| Zoëspores, . . .            | 0         | 17         | 0         | 0         | 0         | 0          | 0          | 0            |
| Fungi, Orenothrix, . . .    | 0         | 2          | 80        | 20        | 0         | 0          | 0          | 0            |
| <b>ANIMALS.</b>             |           |            |           |           |           |            |            |              |
| Infusoria, . . .            | 0         | 38         | 1         | 2         | 8         | 111        | 761        | 1,398        |
| Ceratum, . . .              | 0         | 0          | 0         | 2         | 6         | 0          | 0          | 0            |
| Dinobryon, . . .            | 0         | 0          | 0         | 0         | 0         | 7          | 504        | 1,376        |
| Dinobryon cases, . . .      | 0         | 0          | 0         | 0         | 0         | 104        | 256        | 0            |
| Peridinium, . . .           | 0         | 37         | 0         | 0         | 0         | 0          | 1          | 21           |
| Trachelomonas, . . .        | 0         | 1          | 1         | 0         | 0         | 0          | 0          | 1            |
| Vermes, . . .               | 0         | 1          | 0         | 1         | 0         | 4          | 2          | 5            |
| Anurea, . . .               | 0         | 0          | 0         | 1         | 0         | 4          | 2          | 5            |
| Polyarthra, . . .           | 0         | 1          | 0         | 0         | 0         | 0          | 0          | 0            |
| Miscellaneous, Zoëglæa, . . | 0         | 112        | 0         | 0         | 0         | 3          | 20         | 0            |
| <b>TOTAL, . . .</b>         | <b>11</b> | <b>235</b> | <b>67</b> | <b>27</b> | <b>10</b> | <b>119</b> | <b>785</b> | <b>1,599</b> |

NATICK.

## WATER SUPPLY OF NATICK.

*Chemical Examination of Water from Dug Pond, Natick.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
|         | <b>1895.</b>        |             |                   |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 13505   | Jan. 2              | V. slight.  | V. slight.        | .05    | 5.20                            | 1.15                 | .0184    | .0188       | .0170      | .0018           | .83       | .0050          | .0000     | .2079            | 2.6       |
| 13768   | Feb. 4              | Slight.     | Slight.           | .15    | 6.50                            | 1.40                 | .0054    | .0160       | .0146      | .0014           | .90       | .0550          | .0003     | .2133            | 2.6       |
| 13925   | Mar. 5              | Decided.    | Cons.,<br>earthy. | .15    | 6.45                            | 2.10                 | .0034    | .0166       | .0146      | .0020           | .88       | .0370          | .0000     | .3041            | 2.5       |
| 14070   | Apr. 1              | Slight.     | Cons.,<br>white.  | .18    | 7.00                            | 2.15                 | .0034    | .0156       | .0142      | .0014           | .90       | .0780          | .0002     | .1910            | 2.6       |
| 14228   | May 1               | V. slight.  | Slight.           | .12    | 6.50                            | 2.10                 | .0010    | .0160       | .0132      | .0028           | .86       | .0600          | .0002     | .2040            | 2.7       |
| 14415   | June 3              | Slight.     | Slight.           | .10    | 6.55                            | 2.15                 | .0016    | .0172       | .0132      | .0040           | .88       | .0480          | .0000     | .2546            | 2.5       |
| 14572   | July 1              | Distinct.   | Cons.             | .12    | 6.70                            | 1.75                 | .0014    | .0202       | .0162      | .0040           | .90       | .0280          | .0000     | .2464            | 3.6       |
| 14754   | Aug. 1              | Slight.     | Slight.           | .10    | 6.35                            | 2.15                 | .0006    | .0216       | .0174      | .0042           | .88       | .0100          | .0001     | .2652            | 3.0       |
| 14977   | Sept. 3             | Distinct.   | Slight.           | .08    | 6.35                            | 1.80                 | .0006    | .0250       | .0208      | .0042           | .90       | .0000          | .0003     | .2526            | 2.7       |
| 15301   | Oct. 1              | Slight.     | Slight.           | .10    | 6.00                            | 1.75                 | .0006    | .0222       | .0192      | .0030           | .84       | .0030          | .0000     | .1934            | 2.1       |
| 15473   | Nov. 4              | Distinct.   | Cons.,<br>green.  | .18    | 5.85                            | 1.85                 | .0128    | .0226       | .0198      | .0028           | .84       | .0150          | .0003     | .3159            | 2.3       |
| 15658   | Dec. 2              | Distinct.   | Slight.           | .23    | 5.85                            | 2.00                 | .0040    | .0172       | .0160      | .0012           | .86       | .0350          | .0000     | .2808            | 2.6       |
| Av.     | .....               | .....       | .....             | .13    | 6.27                            | 1.86                 | .0044    | .0191       | .0164      | .0027           | .87       | .0312          | .0001     | .2441            | 2.6       |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | .14 | 5.25 | 1.21 | .0039 | .0215 | -     | -     | .70 | .0050 | -     | -     | -   |
| - | 1888  | - | - | .13 | 5.24 | 1.09 | .0070 | .0228 | -     | -     | .66 | .0197 | .0003 | -     | -   |
| - | 1889  | - | - | .16 | 5.51 | 1.22 | .0044 | .0242 | .0196 | .0046 | .71 | .0289 | .0004 | -     | -   |
| - | 1890  | - | - | .14 | 5.85 | 1.36 | .0027 | .0199 | .0166 | .0033 | .72 | .0227 | .0002 | -     | 2.7 |
| - | 1891  | - | - | .09 | 5.71 | 1.45 | .0085 | .0207 | .0167 | .0040 | .69 | .0326 | .0003 | -     | 2.4 |
| - | 1892  | - | - | .06 | 5.88 | 1.24 | .0068 | .0178 | .0135 | .0038 | .72 | .0323 | .0001 | -     | 2.4 |
| - | 1893  | - | - | .08 | 5.28 | 1.39 | .0062 | .0192 | .0158 | .0034 | .71 | .0193 | .0003 | .2345 | 2.1 |
| - | 1894  | - | - | .10 | 5.64 | 1.65 | .0060 | .0155 | .0132 | .0023 | .80 | .0218 | .0001 | .2124 | 2.3 |
| - | 1895  | - | - | .13 | 6.27 | 1.86 | .0044 | .0191 | .0164 | .0027 | .87 | .0312 | .0001 | .2441 | 2.6 |

\* June to December.

NOTE to analyses of 1895: Odor, generally vegetable, frequently mouldy or unpleasant. — The samples were collected from a faucet at the pumping station.

## NATICK.

*Microscopical Examination of Water from Dug Pond, Natick.*

[Number of organisms per cubic centimeter.]

|                                   | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|-----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                   | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .         | 4     | 7     | 7     | 3     | 2     | 5     | 3     | 3     | 6     | 3     | 6     | 3     |
| Number of sample, . . .           | 13695 | 13768 | 13925 | 14070 | 14228 | 14415 | 14572 | 14754 | 14977 | 15301 | 15473 | 15658 |
| <b>PLANTS.</b>                    |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>Diatomaceæ,</b> . . . .        | 153   | 5     | 32    | 12    | 540   | 344   | 33    | 46    | 28    | 47    | 1,680 | 475   |
| Asterionella, . . . .             | 124   | 0     | 4     | 1     | 140   | 0     | 0     | 0     | 0     | 3     | 3     | 56    |
| Cyclotella, . . . .               | 28    | 1     | 2     | 0     | 100   | 226   | 3     | 1     | 5     | 0     | 2     | 40    |
| Fragilaria, . . . .               | 0     | 0     | 0     | 0     | 4     | 2     | 0     | 1     | 0     | 0     | 0     | 0     |
| Melosira, . . . .                 | 1     | 0     | 26    | 3     | 216   | 27    | 23    | 39    | 21    | 42    | 1,660 | 380   |
| Meridion, . . . .                 | 0     | 2     | 0     | 4     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Synedra, . . . .                  | pr.   | 2     | 0     | 4     | 76    | 50    | 2     | 5     | 2     | 0     | 15    | 0     |
| Tabellaria, . . . .               | 0     | 0     | 0     | 0     | 4     | 39    | 5     | 0     | 0     | 2     | 0     | 0     |
| <b>Cyanophyceæ,</b> . . . .       | 0     | 0     | 0     | 0     | 0     | 1     | 2     | 96    | 241   | 152   | 0     | 0     |
| Chroococcus, . . . .              | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 16    | 0     | 0     |
| Cylindrocapsa, . . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 24    | 9     | 0     | 0     | 0     |
| Microcystis, . . . .              | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 72    | 232   | 136   | 0     | 0     |
| <b>Algae,</b> . . . .             | 0     | 0     | 0     | 0     | 0     | 25    | 146   | 220   | 94    | 23    | 1     | 30    |
| Chlorococcus, . . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 13    | 0     | 0     | 0     |
| Cylindrium, . . . .               | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 28    |
| Protooccus, . . . .               | 0     | 0     | 0     | 0     | 0     | 10    | 143   | 212   | 81    | 23    | 0     | 0     |
| Raphidium, . . . .                | 0     | 0     | 0     | 0     | 0     | 15    | 3     | 0     | 0     | 0     | 1     | 2     |
| Staurogenia, . . . .              | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 8     | 0     | 0     | 0     | 0     |
| <b>Fungi, Crenothrix,</b> . . . . | 0     | 1     | 2     | 0     | 0     | 0     | 4     | 1     | 0     | 0     | 32    | 0     |
| <b>ANIMALS.</b>                   |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>Infusoria,</b> . . . .         | 3     | 1     | 2     | 2     | 78    | 147   | 5     | 0     | 2     | 1     | 276   | 111   |
| Ceratum, . . . .                  | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     |
| Dinobryon, . . . .                | 0     | 0     | 0     | 0     | 0     | 12    | 0     | 0     | 0     | 0     | 196   | 22    |
| Dinobryon cases, . . . .          | 3     | 0     | 0     | 0     | 76    | 135   | 0     | 0     | 0     | 1     | 80    | 85    |
| Peridinium, . . . .               | 0     | 1     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Trachelomonas, . . . .            | pr.   | 0     | 2     | 0     | 0     | 0     | 5     | 0     | 0     | 0     | 0     | 1     |
| <b>Vermes,</b> . . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 2     | 0     | 1     | 0     |
| Anura, . . . .                    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 1     | 0     |
| Rotatorian ova, . . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     |
| <b>TOTAL,</b> . . . .             | 156   | 7     | 36    | 14    | 616   | 517   | 190   | 365   | 367   | 223   | 1,990 | 617   |

## NATICK.

Table showing Heights of Water in Dug Pond on the First of Each Month in 1895.

NOTE.—High-water mark is 13.0 feet.

| 1895.              |  | Height of Water. | 1895.              |  | Height of Water. |
|--------------------|--|------------------|--------------------|--|------------------|
|                    |  | Feet.            |                    |  | Feet.            |
| Jan. 1, . . . . .  |  | 8.63             | July 1, . . . . .  |  | 10.92            |
| Feb. 1, . . . . .  |  | 10.00            | Aug. 1, . . . . .  |  | 9.83             |
| March 1, . . . . . |  | 9.67             | Sept. 1, . . . . . |  | 8.75             |
| April 1, . . . . . |  | 12.92            | Oct. 1, . . . . .  |  | 8.00             |
| May 1, . . . . .   |  | 13.33            | Nov. 1, . . . . .  |  | 9.25             |
| June 1, . . . . .  |  | 12.17            | Dec. 1, . . . . .  |  | 12.50            |

## WATER SUPPLY OF NEEDHAM.

Chemical Examination of Water from the Needham Water Works.

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albu- minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 14213   | 1895.<br>Apr. 24    | None.       | None.     | .00    | 6.70                    | .0000    | .0012         | .87       | .1500       | .0000     | .0079            | 1.9       | .0000 |
| 15414   | Oct. 23             | None.       | None.     | .00    | 5.70                    | .0000    | .0000         | .68       | .1100       | .0000     | .0250            | 1.8       | .0000 |

## Averages by Years.

|   |       |   |   |     |      |       |       |     |       |       |       |     |       |
|---|-------|---|---|-----|------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1891* | - | - | .00 | 6.10 | .0022 | .0022 | .72 | .1500 | .0000 | -     | 1.7 | -     |
| - | 1892† | - | - | .00 | 6.12 | .0000 | .0001 | .65 | .1400 | .0000 | -     | 2.1 | .0072 |
| - | 1893  | - | - | .00 | 5.28 | .0000 | .0007 | .63 | .1230 | .0000 | .0522 | 1.9 | .0000 |
| - | 1894  | - | - | .01 | 5.18 | .0013 | .0006 | .66 | .1367 | .0000 | .0147 | 1.7 | .0020 |
| - | 1895‡ | - | - | .00 | 6.20 | .0000 | .0006 | .78 | .1300 | .0000 | .0165 | 1.8 | .0000 |

\* November.

† July and August.

‡ April and October.

NOTE to analyses of 1895: Odor, none. — The first sample was collected from a faucet at a drinking fountain and the second from a faucet at the pumping station.

## Microscopical Examination.

No. 14213. No organisms.

No. 15414. Fungi, Molds, 3.



## NEW BEDFORD.

## WATER SUPPLY OF NEW BEDFORD.

*Chemical Examination of Water from the Conduit of the New Bedford Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 13694   | 1895.<br>Jan. 21    | V. slight.  | V. slight.        | 1.50   | 5.75                            | 2.50                 | .0022    | .0225       | .0182      | .0046           | .55       | .0050          | .0000     | 2.2340           | 1.4       |
| 13880   | Feb. 25             | V. slight.  | Cons.,<br>brown.  | 1.20   | 5.40                            | 1.90                 | .0020    | .0200       | .0192      | .0008           | .63       | .0070          | .0000     | 1.0625           | 1.3       |
| 14035   | Mar. 25             | V. slight.  | Slight.           | 0.80   | 4.10                            | 1.40                 | .0002    | .0136       | .0114      | .0022           | .52       | .0070          | .0000     | 0.7199           | 1.3       |
| 14195   | Apr. 22             | V. slight.  | Cons.,<br>brown.  | 1.05   | 4.55                            | 2.40                 | .0004    | .0194       | .0180      | .0014           | .53       | .0070          | .0000     | 0.9756           | 1.1       |
| 14370   | May 27              | V. slight.  | Slight.           | 1.35   | 5.20                            | 3.00                 | .0008    | .0246       | .0212      | .0034           | .52       | .0050          | .0000     | 1.2882           | 0.9       |
| 14537   | June 25             | V. slight.  | Slight,<br>rusty. | 1.60   | 5.05                            | 2.85                 | .0012    | .0292       | .0270      | .0022           | .52       | .0030          | .0000     | 1.2320           | 0.9       |
| 14725   | July 29             | Slight.     | Cons.             | 1.10   | 4.55                            | 2.55                 | .0000    | .0262       | .0238      | .0024           | .58       | .0100          | .0000     | 0.9556           | 1.3       |
| 14988   | Sept. 4             | Slight.     | Slight.           | 0.75   | 4.10                            | 1.90                 | .0006    | .0214       | .0192      | .0022           | .51       | .0020          | .0001     | 0.6891           | 0.6       |
| 15231   | Sept. 23            | V. slight.  | Slight.           | 0.60   | 3.95                            | 1.75                 | .0000    | .0212       | .0184      | .0028           | .52       | .0030          | .0000     | 0.5265           | 0.9       |
| 15434   | Oct. 27             | V. slight.  | V. slight.        | 0.30   | 3.50                            | 1.35                 | .0000    | .0208       | .0160      | .0048           | .53       | .0050          | .0000     | 0.4602           | 0.8       |
| 15606   | Nov. 25             | V. slight.  | V. slight.        | 0.62   | 4.35                            | 1.95                 | .0008    | .0206       | .0194      | .0012           | .48       | .0050          | .0001     | 0.6861           | 1.1       |
| 15793   | Dec. 23             | None.       | V. slight.        | 1.20   | 6.15                            | 2.95                 | .0030    | .0262       | .0254      | .0008           | .61       | .0050          | .0000     | 1.2397           | 1.3       |
| Av.     | .....               | .....       | .....             | 1.01   | 4.72                            | 2.21                 | .0009    | .0222       | .0198      | .0024           | .54       | .0053          | .0000     | 1.0083           | 1.1       |

*Averages by Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |        |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|--------|-----|
| - | 1887* | - | - | 1.37 | 5.16 | 1.95 | .0021 | .0296 | -     | -     | .56 | .0137 | -     | -      | -   |
| - | 1888  | - | - | 1.48 | 5.19 | 2.32 | .0014 | .0254 | -     | -     | .53 | .0183 | .0001 | -      | -   |
| - | 1889  | - | - | 1.51 | 3.96 | 1.74 | .0014 | .0241 | .0206 | .0035 | .50 | .0103 | .0001 | -      | -   |
| - | 1890  | - | - | 1.48 | 5.01 | 2.41 | .0013 | .0232 | .0195 | .0037 | .45 | .0125 | .0001 | -      | 1.2 |
| - | 1891  | - | - | 0.95 | 3.90 | 1.81 | .0005 | .0197 | .0171 | .0026 | .42 | .0103 | .0000 | -      | 0.8 |
| - | 1892  | - | - | 1.10 | 4.87 | 2.24 | .0006 | .0227 | .0194 | .0033 | .52 | .0108 | .0001 | -      | 1.0 |
| - | 1893  | - | - | 1.35 | 5.05 | 2.36 | .0022 | .0224 | .0189 | .0035 | .51 | .0051 | .0001 | 1.0440 | 1.0 |
| - | 1894  | - | - | 1.21 | 4.80 | 2.18 | .0012 | .0194 | .0178 | .0016 | .53 | .0058 | .0000 | 0.9882 | 1.0 |
| - | 1895  | - | - | 1.01 | 4.72 | 2.21 | .0009 | .0222 | .0198 | .0024 | .54 | .0053 | .0000 | 1.0083 | 1.1 |

\* June to December.

NOTE to analyses of 1895: Odor, distinctly vegetable. — The samples were collected from the conduit at its entrance to the receiving reservoir, and represent water from the storage reservoir. Water from Little Quittacas Pond was drawn into the storage reservoir from June 24 to July 2, inclusive, and from July 26 to October 7, inclusive.

## NEW BEDFORD.

*Microscopical Examination of Water from the Conduit of the New Bedford Water Works.*

[Number of organisms per cubic centimeter.]

|                                    | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                    | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Sept. | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .          | 23    | 28    | 27    | 23    | 28    | 26    | 31    | 7     | 25    | 30    | 26    | 24    |
| Number of sample, . . .            | 13694 | 13880 | 14035 | 14195 | 14370 | 14537 | 14725 | 14988 | 15231 | 15434 | 15606 | 15793 |
| <b>PLANTS.</b>                     |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, <i>Synedra</i> , . . . | 0     | 2     | 1     | 7     | 4     | 4     | 1     | 0     | 0     | 0     | 0     | 0     |
| Cyanophyceæ, . . .                 | 0     | 0     | 0     | 8     | 0     | 16    | 83    | 81    | 180   | 0     | 0     | 0     |
| <i>Aphanocapsa</i> , . . .         | 0     | 0     | 0     | 8     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| <i>Merismopedia</i> , . . .        | 0     | 0     | 0     | 0     | 0     | 16    | 31    | 81    | 176   | 0     | 0     | 0     |
| <i>Microcystis</i> , . . .         | 0     | 0     | 0     | 0     | 0     | 0     | 52    | 0     | 4     | 0     | 0     | 0     |
| Algæ, . . .                        | 6     | 0     | 0     | 0     | 18    | 10    | 34    | 0     | 13    | 0     | 0     | 0     |
| <i>Chlorococcus</i> , . . .        | 0     | 0     | 0     | 0     | 11    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| <i>Protooccus</i> , . . .          | 6     | 0     | 0     | 0     | 7     | 10    | 34    | 0     | 13    | 0     | 0     | 0     |
| Fungi, . . .                       | 0     | 0     | 0     | 6     | 7     | 11    | 6     | 10    | 0     | 6     | 0     | 1     |
| <i>Crenothrix</i> , . . .          | 0     | 0     | 0     | 6     | 7     | 11    | 6     | 10    | 0     | 0     | 0     | 1     |
| Molds, . . .                       | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 6     | 0     | 0     |
| <b>ANIMALS.</b>                    |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . .                   | 14    | 83    | 10    | 0     | 7     | 0     | 0     | 1     | 0     | 0     | 0     | 0     |
| Dinobryon, . . .                   | 1     | 39    | 8     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, . . .             | 12    | 35    | 0     | 0     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Peridinium, . . .                  | 1     | 4     | 2     | 0     | 4     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| <i>Trachelomonas</i> , . . .       | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 0     |
| Vermes, Anures, . . .              | 0     | 0     | 0     | 0     | 1     | 1     | 0     | 0     | 0     | 0     | 0     | 0     |
| Miscellaneous, Zoöglæa, . . .      | 212   | 32    | 108   | 96    | 108   | 0     | 0     | 0     | 32    | 2     | 0     | 20    |
| TOTAL, . . .                       | 232   | 117   | 119   | 117   | 145   | 42    | 124   | 92    | 225   | 8     | 0     | 21    |

## NEW BEDFORD.

*Chemical Examination of Water from Little Quittacas Pond, Lakeville.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.           |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-----------------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.            | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                       |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 14193   | 1895.<br>Apr. 22    | Slight.               | Cons.,<br>white.  | .17    | 3.15                            | 1.30                 | .0000    | .0142       | .0128      | .0014           | .51       | .0000          | .0000     | .3752            | 0.8       |
| 14987   | Sept. 4             | Slight.               | Slight.           | .15    | 3.15                            | 1.20                 | .0008    | .0196       | .0154      | .0042           | .56       | .0080          | .0000     | .2911            | 0.8       |
| 15821   | Dec. 30             | V. slight,<br>clayey. | Slight,<br>brown. | .22    | 3.20                            | 1.25                 | .0016    | .0150       | .0130      | .0020           | .47       | .0030          | .0000     | .2733            | 0.6       |
| Av.     | .....               | .....                 | .....             | .18    | 3.17                            | 1.25                 | .0008    | .0162       | .0137      | .0025           | .51       | .0037          | .0000     | .3132            | 0.7       |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | .23 | 2.92 | 1.16 | .0008 | .0149 | -     | -     | .51 | .0035 | -     | -     | -   |
| - | 1888† | - | - | .15 | 3.00 | 1.15 | .0003 | .0171 | -     | -     | .48 | .0035 | .0001 | -     | -   |
| - | 1893  | - | - | .11 | 3.02 | 1.23 | .0015 | .0156 | .0128 | .0028 | .48 | .0025 | .0000 | .2904 | 0.6 |
| - | 1894  | - | - | .18 | 2.91 | 0.95 | .0002 | .0168 | .0137 | .0028 | .48 | .0008 | .0000 | .3074 | 0.7 |
| - | 1895  | - | - | .18 | 3.17 | 1.25 | .0008 | .0162 | .0137 | .0025 | .51 | .0037 | .0000 | .3132 | 0.7 |

\* June and September.

† January and May.

NOTE to analyses of 1895: Odor, vegetable. — The samples were collected from the pond.

*Microscopical Examination of Water from Little Quittacas Pond, Lakeville.*

[Number of organisms per cubic centimeter.]

|                                          |  |  |  |  |  | 1895.  |            | 1896.    |
|------------------------------------------|--|--|--|--|--|--------|------------|----------|
|                                          |  |  |  |  |  | April. | September. | January. |
| Day of examination, . . . . .            |  |  |  |  |  | 23     | 7          | 2        |
| Number of sample, . . . . .              |  |  |  |  |  | 14193  | 14987      | 15821    |
| <b>PLANTS.</b>                           |  |  |  |  |  |        |            |          |
| <b>Diatomaceæ,</b> . . . . .             |  |  |  |  |  | 102    | 8          | 5        |
| Asterionella, . . . . .                  |  |  |  |  |  | 57     | 0          | 0        |
| Cyclotella, . . . . .                    |  |  |  |  |  | 11     | 3          | 0        |
| Synedra, . . . . .                       |  |  |  |  |  | 34     | 3          | 5        |
| <b>Cyanophyceæ,</b> . . . . .            |  |  |  |  |  | 0      | 96         | 0        |
| Chroococcus, . . . . .                   |  |  |  |  |  | 0      | 9          | 0        |
| Merismopedia, . . . . .                  |  |  |  |  |  | 0      | 80         | 0        |
| <b>Algæ,</b> . . . . .                   |  |  |  |  |  | 3      | 82         | 0        |
| Protococcus, . . . . .                   |  |  |  |  |  | 0      | 82         | 0        |
| Zoospores, . . . . .                     |  |  |  |  |  | 3      | 0          | 0        |
| <b>ANIMALS.</b>                          |  |  |  |  |  |        |            |          |
| <b>Infusoria,</b> . . . . .              |  |  |  |  |  | 32     | 1          | 0        |
| Dinobryon, . . . . .                     |  |  |  |  |  | 22     | 0          | 0        |
| Dinobryon cases, . . . . .               |  |  |  |  |  | 9      | 0          | 0        |
| Peridinium, . . . . .                    |  |  |  |  |  | 1      | 0          | 0        |
| Trachelomonas, . . . . .                 |  |  |  |  |  | 0      | 1          | 0        |
| <b>Crustacea, Cyclops,</b> . . . . .     |  |  |  |  |  | .12    | 0          | 0        |
| <b>Miscellaneous, Zoöglæa,</b> . . . . . |  |  |  |  |  | 11     | 0          | 20       |
| <b>TOTAL,</b> . . . . .                  |  |  |  |  |  | 148    | 187        | 25       |

## NEW BEDFORD.

*Chemical Examination of Water from Great Quittacas Pond, Lakeville.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.   |                     |             |           |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 14192   | Apr. 22             | V. slight.  | Slight.   | .63    | 3.35                            | 1.50                 | .0002    | .0142       | .0128      | .0014           | .51       | .0030          | .0000     | .6912            | 0.8       |
| 14986   | Sept. 4             | Slight.     | Slight.   | .30    | 3.35                            | 1.05                 | .0000    | .0172       | .0160      | .0012           | .55       | .0000          | .0000     | .4635            | 0.5       |
| 15820   | Dec. 30             | V. slight.  | Slight.   | .27    | 3.20                            | 1.10                 | .0000    | .0148       | .0112      | .0036           | .52       | .0030          | .0000     | .4042            | 0.5       |
| Av.     | .....               | .....       | .....     | .40    | 3.30                            | 1.22                 | .0001    | .0154       | .0133      | .0021           | .53       | .0020          | .0000     | .5196            | 0.6       |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1893* | - | - | .85 | 3.65 | 1.92 | .0000 | .0166 | .0144 | .0022 | .43 | .0018 | .0000 | .7812 | 0.8 |
| - | 1894  | - | - | .49 | 3.30 | 1.35 | .0002 | .0154 | .0139 | .0015 | .50 | .0017 | .0000 | .5031 | 0.6 |
| - | 1895  | - | - | .40 | 3.30 | 1.22 | .0001 | .0154 | .0133 | .0021 | .53 | .0020 | .0000 | .5196 | 0.6 |

\* Five samples, July to September.

NOTE to analyses of 1895: Odor of the first two samples, vegetable; of the last sample, disagreeable. — The samples were collected from the pond.

*Microscopical Examination of Water from Great Quittacas Pond, Lakeville.*

[Number of organisms per cubic centimeter.]

|                                     | 1895.  |            | 1896.    |
|-------------------------------------|--------|------------|----------|
|                                     | April. | September. | January. |
| Day of examination, . . . . .       | 23     | 7          | 2        |
| Number of sample, . . . . .         | 14192  | 14986      | 15820    |
| <b>PLANTS.</b>                      |        |            |          |
| Diatomaceæ, . . . . .               | 45     | 29         | 25       |
| Asterionella, . . . . .             | 41     | 19         | 14       |
| Cyclotella, . . . . .               | 0      | 3          | 0        |
| Fragilaria, . . . . .               | 0      | 0          | 2        |
| Melosira, . . . . .                 | 0      | 0          | 3        |
| Navicula, . . . . .                 | 0      | 2          | 2        |
| Synedra, . . . . .                  | 4      | 5          | 4        |
| Cyanophyceæ, Chroococcus, . . . . . | 0      | 15         | 0        |
| Algeæ, . . . . .                    | 6      | 3          | 0        |
| Chlorococcus, . . . . .             | 3      | 1          | 0        |
| Conferæ, . . . . .                  | 0      | 2          | 0        |
| Zooëporeæ, . . . . .                | 3      | 0          | 0        |
| Fungi, Orenothrix, . . . . .        | 0      | 36         | 0        |
| <b>ANIMALS.</b>                     |        |            |          |
| Infusoria, . . . . .                | 9      | 27         | 3        |
| Dinobryon cases, . . . . .          | 1      | 0          | 0        |
| Peridinium, . . . . .               | 6      | 24         | 3        |
| Pneus, . . . . .                    | 0      | 2          | 0        |
| Tintinnidium, . . . . .             | 0      | 1          | 0        |
| Trachelomonas, . . . . .            | 2      | 0          | 0        |
| Miscellaneous, Zoëglia, . . . . .   | 9      | 0          | 0        |
| TOTAL, . . . . .                    | 69     | 110        | 28       |

## NEW BEDFORD.

*Chemical Examination of Water from Long Pond, Lakeville.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 14194   | 1895.<br>Apr. 22    | Slight.     | Cons.     | 1.10   | 4.10                            | 2.55                 | .0002    | .0212       | .0172      | .0040           | .50       | .0000          | .0000     | 1.0625           | 0.5       |
| 14985   | Sept. 4             | Slight.     | Slight.   | 0.63   | 3.80                            | 1.90                 | .0004    | .0160       | .0148      | .0012           | .62       | .0000          | .0001     | 0.7315           | 0.4       |
| 15819   | Dec. 30             | Distinct.   | Slight.   | 0.93   | 4.30                            | 2.30                 | .0000    | .0200       | .0182      | .0018           | .48       | .0030          | .0000     | 1.0433           | 0.6       |
| Av.     | .....               | .....       | .....     | 0.89   | 4.07                            | 2.25                 | .0002    | .0190       | .0167      | .0023           | .53       | .0010          | .0000     | 0.9458           | 0.5       |

*Averages by Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1891* | - | - | 0.55 | 3.15 | 1.62 | .0000 | .0130 | .0114 | .0016 | .49 | .0020 | .0000 | -     | 0.3 |
| - | 1893† | - | - | 0.85 | 3.65 | 1.92 | .0000 | .0166 | .0144 | .0022 | .43 | .0018 | .0000 | .7812 | 0.3 |
| - | 1894  | - | - | 1.00 | 3.80 | 1.94 | .0002 | .0183 | .0162 | .0021 | .47 | .0013 | .0000 | .9025 | 0.5 |
| - | 1895  | - | - | 0.89 | 4.07 | 2.25 | .0002 | .0190 | .0167 | .0023 | .53 | .0010 | .0000 | .9458 | 0.5 |

\* December, two samples.

† July to September, five samples.

NOTE to analyses of 1895: Odor, vegetable; of the last sample, also mouldy. — The samples were collected from the pond.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in these samples was as follows: No. 14194, 260; No. 14985, 5; No. 15819, 60.

*Table showing Heights of Water in Acushnet Reservoir and Little Quillacas Pond on the First of Each Month in 1895.*

| 1895.              |                                 |                                 | 1895.              |                                 |                                 |
|--------------------|---------------------------------|---------------------------------|--------------------|---------------------------------|---------------------------------|
|                    | Acushnet Reservoir.             | Little Quillacas Pond.          |                    | Acushnet Reservoir.             | Little Quillacas Pond.          |
|                    | Distance below High-water Mark. | Distance below High-water Mark. |                    | Distance below High-water Mark. | Distance below High-water Mark. |
| Jan. 1, . . . . .  | Feet.<br>0.00                   | Feet.<br>2.67                   | July 1, . . . . .  | Feet.<br>0.17                   | Feet.<br>1.33                   |
| Feb. 1, . . . . .  | 0.00                            | 1.75                            | Aug. 1, . . . . .  | 0.58                            | 1.50                            |
| March 1, . . . . . | 0.00                            | 1.42                            | Sept. 1, . . . . . | 0.67                            | 3.00                            |
| April 1, . . . . . | 0.00                            | 1.08                            | Oct. 1, . . . . .  | 0.67                            | 4.67                            |
| May 1, . . . . .   | 0.00                            | 1.00                            | Nov. 1, . . . . .  | 0.75                            | 4.00                            |
| June 1, . . . . .  | 0.00                            | 0.92                            | Dec. 1, . . . . .  | 0.25                            | 3.43                            |

## NEWBURYPORT.

## WATER SUPPLY OF NEWBURYPORT.

The works of the Newburyport Water Company were taken by city Feb. 1, 1895.

*Chemical Examination of Water from a Faucet in Newburyport, supplied from the Newburyport Water Works.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE.       |               |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------------------|-------------------|---------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|                     | Turbidity.        | Sediment.     | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| <b>1895.</b>        |                   |               |        |                         |          |             |           |             |           |                  |           |       |
| Jan. 15             | V. slight.        | V. slight.    | .20    | 6.40                    | .0002    | .0028       | 0.45      | .0180       | .0000     | .0869            | 2.5       | .0260 |
| Feb. 19             | Slight.           | Slight.       | .25    | 5.60                    | .0008    | .0020       | 0.44      | .0150       | .0000     | .0780            | 2.2       | .0620 |
| Mar. 19             | V. slight, milky. | V. slight.    | .15    | 5.30                    | .0000    | .0044       | 0.40      | .0120       | .0000     | .1185            | 2.3       | .0150 |
| Apr. 16             | Slight, milky.    | V. slight.    | .12    | 4.90                    | .0000    | .0030       | 0.42      | .0150       | .0000     | .1359            | 2.4       | .0150 |
| May 20              | Slight, milky.    | Slight.       | .15    | 5.10                    | .0000    | .0024       | 0.42      | .0220       | .0000     | .0806            | 2.3       | .0300 |
| June 19             | Slight, milky.    | V. slight.    | .20    | 5.90                    | .0010    | .0070       | 1.91      | .0080       | .0000     | .1092            | 2.2       | .0350 |
| July 23             | Distinct, milky.  | None.         | .20    | 6.00                    | .0000    | .0040       | 0.55      | .0180       | .0000     | .0937            | 3.0       | .0250 |
| Aug. 20             | Slight, milky.    | V. slight.    | .08    | 6.50                    | .0000    | .0020       | 0.46      | .0200       | .0000     | .0468            | 2.3       | .0250 |
| Sept. 17            | Slight.           | Slight.       | .18    | 6.50                    | .0004    | .0046       | 0.80      | .0150       | .0000     | .0998            | 2.3       | .0280 |
| Oct. 15             | Distinct, milky.  | Slight, floe. | .32    | 6.80                    | .0000    | .0118       | 0.51      | .0150       | .0001     | .3315            | 2.3       | .0530 |
| Nov. 19             | Slight, milky.    | Slight.       | .20    | 6.00                    | .0000    | .0064       | 0.48      | .0150       | .0000     | .2223            | 2.6       | .0220 |
| Dec. 17             | Distinct.         | V. slight.    | .13    | 6.50                    | .0000    | .0036       | 0.46      | .0180       | .0000     | .1808            | 2.3       | .0260 |
| .....               | .....             | .....         | .18    | 5.96                    | .0002    | .0045       | 0.61      | .0159       | .0000     | .1320            | 2.4       | .0302 |

*Averages by Years.*

|          |   |   |     |      |       |       |       |       |       |       |     |       |
|----------|---|---|-----|------|-------|-------|-------|-------|-------|-------|-----|-------|
| 1887-88* | - | - | .03 | 5.39 | .0004 | .0032 | 0.45  | .0312 | .0001 | -     | -   | -     |
| 1893†    | - | - | .11 | 8.50 | .0013 | .0048 | 3.44† | .0178 | .0000 | .1391 | 2.7 | .0164 |
| 1894     | - | - | .13 | 6.00 | .0001 | .0039 | 0.46  | .0133 | .0000 | .0860 | 2.3 | .0368 |
| 1895     | - | - | .18 | 5.96 | .0002 | .0045 | 0.61  | .0159 | .0000 | .1320 | 2.4 | .0302 |

\*June, 1887, to May, 1888.

†The very high chlorine present in the water in 1893 was due to the use at times of water from the Mack River which contained a small amount of sea water.

As to analyses of 1895: Odor in May and October, vegetable; at other times, none. In January, February, March, April and September a vegetable odor was developed on heating. — The samples collected from a faucet at No. 2 State Street.

*Microscopical Examination.*

Insignificant number of organisms was found in these samples.

## NEWTON.

## WATER SUPPLY OF NEWTON.

*Chemical Examination of Water from a Faucet at the Newton Water Works Pumping Station.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.    |                 |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|----------------|-----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.     | Sediment.       | Color. |                         | Free.    | Albaminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1895.</b>        |                |                 |        |                         |          |             |           |             |           |                  |           |       |
| 13648   | Jan. 14             | None.          | None.           | .00    | 5.80                    | .0000    | .0052       | .44       | .0200       | .0000     | .0513            | 2.9       | .0030 |
| 13839   | Feb. 19             | None.          | Slight.         | .00    | 5.80                    | .0000    | .0014       | .39       | .0200       | .0000     | .0312            | 2.5       | .0170 |
| 13988   | Mar. 18             | V. slight.     | Slight.         | .05    | 6.20                    | .0000    | .0012       | .41       | .0200       | .0000     | .0355            | 2.5       | .0300 |
| 14162   | Apr. 17             | Slight, milky. | Slight.         | .04    | 5.40                    | .0000    | .0016       | .41       | .0220       | .0000     | .0908            | 2.6       | .0280 |
| 14331   | May 21              | V. slight.     | V. slight.      | .03    | 5.70                    | .0000    | .0002       | .36       | .0230       | .0000     | .0395            | 2.2       | .0100 |
| 14506   | June 20             | V. slight.     | Slight, earthy. | .05    | 6.70                    | .0000    | .0018       | .36       | .0120       | .0000     | .0234            | 1.9       | .0300 |
| 14696   | July 24             | None.          | V. slight.      | .02    | 5.40                    | .0000    | .0042       | .44       | .0230       | .0000     | .1155            | 2.6       | .0100 |
| 14885   | Aug. 21             | V. slight.     | V. slight.      | .03    | 5.60                    | .0000    | .0026       | .40       | .0170       | .0000     | .0624            | 2.1       | .0050 |
| 15203   | Sept. 18            | None.          | None.           | .02    | 5.40                    | .0002    | .0020       | .41       | .0170       | .0000     | .0546            | 2.2       | .0090 |
| 15407   | Oct. 21             | Slight.        | Slight.         | .10    | 6.30                    | .0000    | .0032       | .45       | .0200       | .0000     | .0796            | 2.7       | .0180 |
| 15678   | Nov. 20             | None.          | V. slight       | .03    | 7.00                    | .0006    | .0016       | .49       | .0320       | .0000     | .0608            | 2.9       | .0080 |
| 15737   | Dec. 17             | V. slight.     | V. slight.      | .03    | 4.90                    | .0004    | .0026       | .43       | .0500       | .0000     | .0346            | 2.1       | .0070 |
| Av.     | .....               | .....          | .....           | .03    | 5.85                    | .0001    | .0023       | .42       | .0230       | .0000     | .0566            | 2.4       | .0146 |

*Averages by Years.*

|   |       |   |   |     |      |       |       |     |       |       |       |     |       |
|---|-------|---|---|-----|------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1887* | - | - | .00 | 4.97 | .0005 | .0070 | .38 | .0047 | -     | -     | -   | -     |
| - | 1888  | - | - | .01 | 4.64 | .0009 | .0111 | .35 | .0072 | .0001 | -     | -   | -     |
| - | 1889  | - | - | .00 | 3.93 | .0002 | .0061 | .30 | .0126 | .0001 | -     | -   | -     |
| - | 1890† | - | - | .00 | -    | .0000 | .0014 | .32 | .0250 | .0001 | -     | -   | -     |
| - | 1891† | - | - | .00 | 4.25 | .0002 | .0072 | .31 | .0250 | .0000 | -     | 1.8 | -     |
| - | 1892  | - | - | .02 | 5.13 | .0006 | .0028 | .35 | .0190 | .0001 | -     | 2.4 | -     |
| - | 1893  | - | - | .03 | 5.08 | .0004 | .0019 | .38 | .0194 | .0000 | .0856 | 2.3 | .0119 |
| - | 1894  | - | - | .03 | 5.99 | .0001 | .0021 | .40 | .0157 | .0000 | .0542 | 2.7 | .0110 |
| - | 1895  | - | - | .03 | 5.85 | .0001 | .0023 | .42 | .0230 | .0000 | .0566 | 2.4 | .0146 |

\* June to December.

† February.

NOTE to analyses of 1895: Odor, none. — The samples were collected from a faucet at the pump ing station.

Analyses for the years 1887 to 1890, inclusive, represent water drawn from an open filter-basin. In 1890 the works for collecting ground water were enlarged by the construction of a long wooden filter-gallery, reinforced by tubular wells. A portion of this gallery, 732 feet in length, replaced an equal portion of the old open filter-basin. In 1892 the remaining portion of the open filter-basin was replaced by an extension of the filter-gallery, and after December of that year the water pumped for the supply of the city was not exposed to light at any point. In 1894 the works were again enlarged by the construction of a collecting conduit 3,268 feet long and by driving 52 tubular wells which are connected with the conduit.

NEWTON.

*Microscopical Examination of Water from a Faucet at the Newton Water Works Pumping Station.*

[Number of organisms per cubic centimeter.]

|                               | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|-------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                               | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .     | 15    | 20    | 19    | -     | 21    | 21    | 25    | 22    | 19    | 23    | 21    | 18    |
| Number of sample, . . .       | 13648 | 13839 | 13988 | 14162 | 14331 | 14506 | 14696 | 14885 | 15203 | 15407 | 15578 | 15737 |
| PLANTS.                       |       |       |       |       |       |       |       |       |       |       |       |       |
| Fungi, Crenothrix, . . .      | 2     | 24    | 26    | -     | 0     | 2     | 0     | 38    | 0     | 128   | 2     | 10    |
| Miscellaneous, Zoöglon, . . . | 0     | 0     | 0     | -     | 0     | 0     | 0     | 52    | 0     | 0     | 0     | 0     |
| TOTAL, . . .                  | 2     | 24    | 26    | -     | 0     | 2     | 0     | 90    | 0     | 128   | 2     | 10    |

*Chemical Examination of Water from the Covered Distributing Reservoir of the Newton Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.      | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | 1895.               |             |                |        |                         |          |             |           |             |           |                  |           |       |
| 13647   | Jan. 14             | V. slight.  | Cons., rusty.  | .02    | 4.80                    | .0006    | .0088       | .42       | .0150       | .0000     | .1043            | 2.6       | .0400 |
| 13840   | Feb. 19             | V. slight.  | Slight.        | .02    | 5.80                    | .0002    | .0028       | .41       | .0170       | .0000     | .0312            | 2.5       | .0280 |
| 13999   | Mar. 18             | None.       | Slight, rusty. | .00    | 5.30                    | .0002    | .0016       | .40       | .0200       | .0000     | .0411            | 2.6       | .0130 |
| 4163    | Apr. 17             | None.       | Slight.        | .00    | 6.50                    | .0000    | .0016       | .39       | .0170       | .0000     | .0355            | 3.0       | .0130 |
| 4332    | May 21              | Slight.     | Cons., rusty.  | .02    | 6.10                    | .0000    | .0050       | .38       | .0250       | .0000     | .0592            | 3.1       | .0280 |
| 4697    | July 24             | None.       | V. slight.     | .02    | 6.10                    | .0000    | .0020       | .44       | .0130       | .0000     | .0847            | 3.4       | .0090 |
| 4884    | Aug. 21             | Slight.     | Slight.        | .03    | 7.50                    | .0000    | .0038       | .42       | .0100       | .0000     | .0858            | 3.6       | .0030 |
| 5204    | Sept. 18            | None.       | None.          | .02    | 7.60                    | .0012    | .0028       | .40       | .0130       | .0000     | .0936            | 3.4       | .0030 |
| 5408    | Oct. 21             | V. slight.  | Cons.          | .06    | 8.10                    | .0000    | .0050       | .44       | .0180       | .0000     | .0858            | 4.0       | .0700 |
| 5579    | Nov. 20             | None.       | V. slight.     | .05    | 7.50                    | .0008    | .0032       | .54       | .0220       | .0000     | .0780            | 3.4       | .0110 |
| 5758    | Dec. 17             | V. slight.  | V. slight.     | .05    | 7.10                    | .0014    | .0038       | .49       | .0470       | .0000     | .0477            | 3.2       | .0340 |
| Avg.    | .....               | .....       | .....          | .03    | 6.58                    | .0004    | .0037       | .43       | .0197       | .0000     | .0679            | 3.2       | .0229 |

*Averages by Years.*

|   |      |   |   |     |      |       |       |     |       |       |       |     |       |
|---|------|---|---|-----|------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1892 | - | - | .03 | 6.40 | .0022 | .0038 | .35 | .0246 | .0003 | -     | 3.0 | .0242 |
| - | 1893 | - | - | .04 | 6.40 | .0000 | .0027 | .38 | .0220 | .0000 | .0678 | 3.0 | .0196 |
| - | 1894 | - | - | .03 | 6.44 | .0002 | .0038 | .40 | .0149 | .0000 | .0680 | 2.9 | .0352 |
| - | 1895 | - | - | .03 | 6.58 | .0004 | .0037 | .43 | .0197 | .0000 | .0679 | 3.2 | .0229 |

NOTE to analyses of 1895: Odor, in March and November, faintly unpleasant; in May and October, distinctly unpleasant; at other times, none; on heating, a distinctly unpleasant odor was developed in the May sample and a distinctly disagreeable odor in the December sample. — The samples were taken from the reservoir.



**NEWTON.***Microscopical Examination of Water from the Covered Distributing Reservoir of the Newton Water Works.*

[Number of organisms per cubic centimeter.]

|                                   | 1895. |       |       |       |       |       |       |       |       |       |       |  |
|-----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--|
|                                   | Jan.  | Feb.  | Mar.  | Apr.  | May.  | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |  |
| Day of examination, . . . . .     | 15    | 20    | 19    | -     | 21    | 26    | 22    | 21    | 23    | 21    | 18    |  |
| Number of sample, . . . . .       | 13647 | 13840 | 13989 | 14163 | 14332 | 14697 | 14884 | 15204 | 15408 | 15579 | 15738 |  |
| PLANTS.                           |       |       |       |       |       |       |       |       |       |       |       |  |
| Algæ, Zoöspores, . . . . .        | 0     | 0     | 0     | -     | 0     | 0     | 0     | 5     | 0     | 0     | 0     |  |
| Fungi, Crenothrix, . . . . .      | 84    | 20    | 30    | -     | 44    | 3     | 156   | 192   | 2     | 0     | 0     |  |
| ANIMALS.                          |       |       |       |       |       |       |       |       |       |       |       |  |
| Infusoria, Trachelomonas, . . . . | 0     | 0     | 0     | -     | 0     | 0     | 0     | 2     | 0     | 0     | 0     |  |
| Miscellaneous, Zoöglæa, . . . . . | 0     | 0     | 0     | -     | 96    | 0     | 3     | 0     | 0     | 10    | 0     |  |
| TOTAL, . . . . .                  | 84    | 20    | 30    | -     | 140   | 3     | 159   | 199   | 2     | 10    | 0     |  |

*Chemical Examination of Water from a Faucet in Newton supplied from the Newton Water Works.*

[Parts per 100,000.]

| Number. | Date of<br>Collection. | APPEARANCE. |           |        | Residue on<br>Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN<br>AS |           | Oxygen<br>Consumed. | Hardness. | Iron. |
|---------|------------------------|-------------|-----------|--------|----------------------------|----------|------------------|-----------|----------------|-----------|---------------------|-----------|-------|
|         |                        | Turbidity.  | Sediment. | Color. |                            | Free.    | Albu-<br>minoid. |           | Nitrates.      | Nitrites. |                     |           |       |
|         |                        |             |           |        |                            |          |                  |           |                |           |                     |           |       |
| 14507   | 1895.<br>June 20       | V. slight.  | None.     | .03    | 5.50                       | .0000    | .0014            | .35       | .0170          | .0000     | .0078               | 1.8       | .0090 |

Odor, none. — The sample was collected from a faucet at Newton Upper Falls.

*Microscopical Examination.*Algæ, *Protococcus*, 10.

NEWTON.

*Chemical Examination of Water from the Main Underdrain of the Hyde Brook  
Division of the Newton Sewerage System.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.      | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 14175   | 1895.<br>Apr. 17    | None.       | Cons., earthy. | .01    | 21.90                   | .0120    | .0048       | 2.20      | .6600       | .0007     | .0750            | 8.1       | .0020 |
| 14883   | Aug. 21             | V. slight.  | None.          | .02    | 34.40                   | .0000    | .0022       | 3.25      | .4850       | .0008     | .0468            | 12.4      | .0050 |
| 15767   | Dec. 18             | Distinct.   | Slight, rusty. | .04    | 20.90                   | .0096    | .0026       | 1.87      | .5400       | .0001     | .0385            | 8.7       | .0400 |
| Av.     | .....               | .....       | .....          | .02    | 25.73                   | .0072    | .0032       | 2.44      | .5583       | .0005     | .0534            | 9.7       | .0157 |

*Averages by Years.*

|   |       |   |   |     |       |       |       |      |        |       |       |      |       |
|---|-------|---|---|-----|-------|-------|-------|------|--------|-------|-------|------|-------|
| - | 1891* | - | - | .00 | 26.05 | .0200 | .0036 | 3.15 | 1.5000 | .0050 | -     | 10.7 | -     |
| - | 1892  | - | - | .00 | 27.08 | .0126 | .0029 | 3.18 | 1.1666 | .0015 | -     | 10.1 | .0082 |
| - | 1893  | - | - | .03 | 25.43 | .0140 | .0037 | 2.48 | 0.9560 | .0018 | .0640 | 9.4  | .0099 |
| - | 1894  | - | - | .03 | 26.27 | .0105 | .0034 | 2.67 | 0.9933 | .0012 | .0451 | 9.2  | .0033 |
| - | 1895  | - | - | .02 | 25.73 | .0072 | .0032 | 2.44 | 0.5683 | .0005 | .0534 | 9.7  | .0157 |

\* December.

NOTE to analyses of 1895: Odor, none.—The samples were collected from the underdrain at its outlet.

*Microscopical Examination.*

No. 14175. Fungi, *Crenothrix*, 7.

No. 14883. Fungi, *Crenothrix*, 2. Infusoria, *Peridinium*, 1. Miscellaneous, *Zoöglaa*, 9. Total, 12.

No. 15767. Fungi, *Crenothrix*, 102.

*Chemical Examination of Water from the Main Underdrain of the Cheesecake  
Brook Division of the Newton Sewerage System.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.    |                |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|----------------|----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.     | Sediment.      | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 174     | 1895.<br>Apr. 17    | None.          | Slight.        | .04    | 18.30                   | .0142    | .0050       | 1.42      | .3650       | .0007     | .0160            | 8.3       | .0160 |
| 881     | Aug. 21             | Slight, milky. | Slight, rusty. | .04    | 20.40                   | .0176    | .0014       | 1.84      | .2350       | .0005     | .0280            | 6.6       | .0280 |
| 768     | Dec. 18             | Distinct.      | Slight, rusty. | .02    | 19.20                   | .0058    | .0050       | 1.25      | .3500       | .0001     | .0447            | 8.0       | .0420 |
| Av.     | .....               | .....          | .....          | .03    | 19.30                   | .0125    | .0038       | 1.50      | .3167       | .0004     | .0296            | 7.6       | .0287 |

*Averages by Years.*

|   |       |   |   |     |       |       |       |      |       |       |       |     |       |
|---|-------|---|---|-----|-------|-------|-------|------|-------|-------|-------|-----|-------|
| - | 1893* | - | - | .08 | 15.83 | .0075 | .0016 | 1.51 | .3225 | .0006 | .0217 | 6.0 | .0520 |
| - | 1894  | - | - | .04 | 20.63 | .0265 | .0040 | 2.05 | .5667 | .0030 | .0489 | 7.9 | .0340 |
| - | 1896  | - | - | .03 | 19.30 | .0125 | .0038 | 1.50 | .3167 | .0004 | .0296 | 7.6 | .0287 |

\* July to December.

NOTE to analyses of 1895: Odor, none, becoming distinctly unpleasant in the second sample on heat.—The samples were collected from the underdrain at its outlet.

*Microscopical Examination.*

No. 14174. Fungi, *Crenothrix*, 180.

No. 14881. Fungi, *Crenothrix*, 82. Infusoria, *Peridinium*, 1. Miscellaneous, *Zoöglaa*, 8. Total, 91.

No. 15766. Fungi, *Crenothrix*, 210.

## NEWTON.

*Chemical Examination of Water from the Main Underdrain Beneath the Laundry Brook Valley Sewer, Newton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment.      | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 14176   | 1895.<br>Apr. 17    | V. slight.       | Cons., rusty.  | .03    | 19.10                   | .0164    | .0110       | 1.90      | 0.4350      | .0004     | .0869            | 8.3       | .1400 |
| 14882   | Aug. 21             | Slight.          | Slight, rusty. | .04    | 20.50                   | .0078    | .0018       | 2.30      | 0.4000      | .0002     | .0250            | 6.7       | .0250 |
| 15766   | Dec. 18             | Decided, clayey. | Cons., earthy. | .03    | 25.50                   | .0074    | .0074       | 2.07      | 1.0300      | .0013     | .0216            | 10.4      | .0000 |
| Av.     | .....               | .....            | .....          | .03    | 21.70                   | .0105    | .0067       | 2.09      | 0.6217      | .0006     | .0445            | 8.5       | .0550 |

*Averages by Years.*

|   |       |   |   |     |       |       |       |      |        |       |       |     |       |
|---|-------|---|---|-----|-------|-------|-------|------|--------|-------|-------|-----|-------|
| - | 1893* | - | - | .08 | 16.90 | .0082 | .0026 | 1.51 | 0.3500 | .0006 | .0782 | 7.1 | .0625 |
| - | 1894  | - | - | .04 | 17.23 | .0103 | .0019 | 1.68 | 0.3767 | .0006 | .0509 | 6.8 | .0447 |
| - | 1895  | - | - | .03 | 21.70 | .0105 | .0067 | 2.09 | 0.6217 | .0006 | .0445 | 8.5 | .0550 |

\* October and December.

NOTE to analyses of 1895: Odor, none. — The samples were collected from the underdrain at its outlet.

*Microscopical Examination.*

No. 14176. Fungi, *Crenothrix*, 380. Miscellaneous, *Zoöglæa*, 18. Total, 398.

No. 14882. Fungi, *Crenothrix*, 1,760.

No. 15766. Algae, *Zoöspores*, 1.

## WATER SUPPLY OF NORTH ADAMS.

*Chemical Examination of Water from Notch Brook and Broad Brook.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 15268   | 1895.<br>Sept. 26   | None.       | Slight.    | .08    | 11.00                           | 2.25                 | .0000    | .0026       | .0024      | .0002           | .10       | .0030          | .0000     | .0780            | 5.6       |
| 15272   | Sept. 27            | V. slight.  | V. slight. | .03    | 4.80                            | 0.65                 | .0000    | .0048       | .0038      | .0010           | .06       | .0030          | .0000     | .1108            | 3.5       |

Odor of the first sample, none; of the last, faintly musty, disappearing on heating. — The first sample was collected from Notch Brook, just above the point where the supply is taken for North Adams; the last, from Broad Brook at point where supply is taken.

*Microscopical Examination.*

No. 15268. Diatomaceæ, *Fragilaria*, 3; *Navicula*, 4; *Pinnularia*, 1; *Surirella*, 1; *Synedra*, 3. Cyanophycæ, *Oscillaria*, 1. Fungi, *Crenothrix*, 400. Total, 413.

No. 15272. Diatomaceæ, *Melosira*, 3.

## NORTH ADAMS.

*Chemical Examination of Water from Tubular Wells used as an Auxiliary Supply for North Adams.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 15269   | 1895.<br>Sept. 26   | None.       | V. slight. | .00    | 27.50                   | .0000    | .0000       | .35       | .3150       | .0000     | .0039            | 20.0      | .0020 |

Odor, none. — The sample was collected from the pump drawing water from the wells.

*Microscopical Examination.*

Fungi, *Crenothrix*, 1.

## WATER SUPPLY OF NORTHAMPTON.

*Chemical Examination of Water from the Upper Storage Reservoir of the Northampton Water Works on Roberts' Meadow Brook.*

[Parts per 100,000.]

| Number, | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 4451    | 1895.<br>June 10    | V. slight.  | Slight.    | .30    | 4.35                    | 1.95              | .0002    | .0112       | .0090      | .0022      | .09       | .0050       | .0001     | .4251            | 1.6       |
| 5209    | Sept. 17            | Distinct.   | Slight.    | .15    | 4.45                    | 0.85              | .0006    | .0104       | .0066      | .0038      | .16       | .0000       | .0000     | .2457            | 2.2       |
| 4416    | Oct. 22             | Slight.     | Slight.    | .40    | 5.25                    | 1.75              | .0006    | .0146       | .0134      | .0012      | .16       | .0030       | .0001     | .5889            | 2.1       |
| 4641    | Nov. 29             | None.       | V. slight. | .47    | 3.85                    | 1.25              | .0004    | .0084       | .0068      | .0016      | .12       | .0020       | .0000     | .5460            | 1.3       |
| 4815    | Dec. 25             | Slight.     | Slight.    | .47    | 3.95                    | 1.50              | .0006    | .0144       | .0123      | .0016      | .11       | .0030       | .0000     | .6044            | 1.1       |
| 4815    | .....               | .....       | .....      | .36    | 4.37                    | 1.46              | .0005    | .0118       | .0097      | .0021      | .13       | .0026       | .0000     | .4820            | 1.7       |

Odor, faintly vegetable. — The samples were collected from the reservoir about 1 foot beneath surface.

*Microscopical Examination.*

The average number of organisms found in these samples was 176.

**NORTHAMPTON.***Chemical Examination of Water from Roberts' Meadow Brook, just above the Middle Reservoir of the Northampton Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 14759   | 1893.<br>Aug. 1     | V. slight.  | Slight.    | .40    | 5.25                            | 1.50                 | .0008    | .0140       | .0132      | .0008           | .14       | .0050          | .0000     | .6084            | 3.1       |
| 14927   | Aug. 27             | None.       | V. slight. | .28    | 5.70                            | 1.70                 | .0004    | .0108       | .0088      | .0020           | .14       | .0050          | .0003     | .2808            | 1.8       |
| 15210   | Sept. 17            | V. slight.  | Slight.    | .17    | 4.55                            | 0.90                 | .0004    | .0078       | .0054      | .0024           | .15       | .0030          | .0000     | .1856            | 2.2       |
| 15417   | Oct. 22             | V. slight.  | Slight.    | .35    | 5.05                            | 1.65                 | .0002    | .0132       | .0110      | .0022           | .16       | .0030          | .0002     | .4992            | 2.1       |
| 15642   | Nov. 29             | None.       | V. slight. | .49    | 3.75                            | 1.35                 | .0000    | .0104       | .0074      | .0030           | .14       | .0000          | .0000     | .5343            | 1.3       |
| 15818   | Dec. 28             | Slight.     | Slight.    | .50    | 4.00                            | 1.65                 | .0010    | .0232       | .0216      | .0016           | .12       | .0030          | .0000     | .5867            | 1.1       |
| Av.     | .....               | .....       | .....      | .36    | 4.72                            | 1.46                 | .0005    | .0132       | .0112      | .0020           | .14       | .0032          | .0001     | .4492            | 1.9       |

Odor, faintly vegetable or none, generally somewhat stronger on heating. — The samples were collected from the stream, just above the reservoir.

*Microscopical Examination of Water from Roberts' Meadow Brook, just above the Middle Reservoir of the Northampton Water Works.*

[Number of organisms per cubic centimeter.]

|                                    | 1893. |       |       |       |       |       |
|------------------------------------|-------|-------|-------|-------|-------|-------|
|                                    | Aug.  | Aug.  | Sept. | Oct.  | Dec.  | Dec.  |
| Day of examination, . . . . .      | 6     | 30    | -     | 25    | 2     | 31    |
| Number of sample, . . . . .        | 14759 | 14927 | 15210 | 15417 | 15642 | 15818 |
| <b>PLANTS.</b>                     |       |       |       |       |       |       |
| Diatomaceæ, . . . . .              | 31    | 520   | -     | 0     | 1     | 0     |
| Cyclotella, . . . . .              | 6     | 520   | -     | 0     | 0     | 0     |
| Navicula, . . . . .                | 5     | 0     | -     | 0     | 0     | 0     |
| Pinnularia, . . . . .              | 5     | 0     | -     | 0     | 0     | 0     |
| Synedra, . . . . .                 | 15    | 0     | -     | 0     | 1     | 0     |
| Algae, Raphidium, . . . . .        | 12    | 0     | -     | 0     | 0     | 0     |
| Fungi, Crenothrix, . . . . .       | 4     | 48    | -     | 92    | 2     | 1     |
| Miscellaneous, Zoöglaea, . . . . . | 0     | 0     | -     | 6     | 0     | 10    |
| TOTAL, . . . . .                   | 47    | 568   | -     | 98    | 3     | 11    |

## NORTHAMPTON.

*Chemical Examination of Water from the Middle Storage Reservoir of the Northampton Water Works on Roberts' Meadow Brook, collected near the Surface.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.          |                  |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|----------------------|------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.           | Sediment.        | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                      |                  |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 152     | 1895.<br>June 10    | V. slight.           | Slight.          | .40    | 4.05                            | 1.75                 | .0006    | .0158       | .0142      | .0016           | .10       | .0030          | .0001     | .5164            | 1.7       |
| '60     | Aug. 1              | V. slight.           | Cons.,<br>green. | .40    | 5.00                            | 1.65                 | .0004    | .0198       | .0144      | .0054           | .15       | .0030          | .0000     | .5616            | 2.3       |
| 28      | Aug. 27             | V. slight.           | Slight.          | .40    | 4.65                            | 1.55                 | .0000    | .0176       | .0154      | .0022           | .11       | .0000          | .0000     | .4602            | 1.8       |
| 112     | Sept. 17            | Distinct,<br>green.  | Slight.          | .67    | 4.85                            | 1.55                 | .0002    | .0186       | .0146      | .0040           | .12       | .0030          | .0000     | .4493            | 2.3       |
| 118     | Oct. 22             | Distinct.            | Cons.,<br>brown. | .90    | 5.25                            | 2.35                 | .0040    | .0246       | .0234      | .0012           | .17       | .0050          | .0001     | .9766            | 1.8       |
| 543     | Nov. 29             | Slight.              | Slight.          | .70    | 4.25                            | 1.65                 | .0000    | .0124       | .0112      | .0012           | .14       | .0030          | .0000     | .7176            | 1.3       |
| 116     | Dec. 28             | Distinct,<br>clayey. | Slight.          | .50    | 3.90                            | 1.55                 | .0002    | .0178       | .0156      | .0022           | .10       | .0000          | .0000     | .6160            | 1.1       |
| 57      | .....               | .....                | .....            | .57    | 4.56                            | 1.72                 | .0008    | .0181       | .0156      | .0025           | .13       | .0024          | .0000     | .6140            | 1.8       |

Odor as follows: in June, distinctly vegetable and unpleasant; on August 1, distinctly vegetable and unpleasant; on August 27, disagreeable; in September and December, none, becoming vegetable heating; in October and November, faintly vegetable, becoming stronger on heating.—The samples were collected from the reservoir at depths of from 6 inches to 2 feet beneath the surface.

*Microscopical Examination of Water from the Middle Storage Reservoir of the Northampton Water Works on Roberts' Meadow Brook, collected near the Surface.*

[Number of organisms per cubic centimeter.]

|                                | 1895. |        |       |       |       |       |       |
|--------------------------------|-------|--------|-------|-------|-------|-------|-------|
|                                | June. | Aug.   | Aug.  | Sept. | Oct.  | Dec.  | Dec.  |
| Days of examination, . . . . . | 12    | 6      | 30    | 21    | 25    | 2     | 31    |
| Number of sample, . . . . .    | 14452 | 14760  | 14928 | 15212 | 15418 | 15643 | 15816 |
| PLANTS.                        |       |        |       |       |       |       |       |
| Stomatocera, . . . . .         | 3     | 10,019 | 1,727 | 2,336 | 196   | 4     | 6     |
| Cyclotella, . . . . .          | 0     | 10,000 | 1,720 | 2,280 | 192   | 0     | 0     |
| Navicula, . . . . .            | 0     | 5      | 1     | 4     | 2     | 0     | 0     |
| Pinnularia, . . . . .          | 0     | 5      | 0     | 0     | 0     | 0     | 0     |
| Synedra, . . . . .             | 2     | 8      | 6     | 52    | 2     | 4     | 2     |
| Tabellaria, . . . . .          | 1     | 1      | 0     | 0     | 0     | 0     | 4     |
| Grac, . . . . .                | 346   | 40     | 2     | 2     | 0     | 0     | 0     |
| Protococci, . . . . .          | 346   | 0      | 0     | 0     | 0     | 0     | 0     |
| Staurastrum, . . . . .         | 0     | 40     | 2     | 2     | 0     | 0     | 0     |
| Engl, . . . . .                | 0     | 36     | 0     | 2     | 36    | 6     | 2     |
| Oreothrix, . . . . .           | 0     | 36     | 0     | 2     | 36    | 2     | 2     |
| Molds, . . . . .               | 0     | 0      | 0     | 0     | 0     | 4     | 0     |

## NORTHAMPTON.

*Microscopical Examination of Water from the Middle Storage Reservoir of the Northampton Water Works on Roberts' Meadow Brook, collected near the Surface — Concluded.*

[Number of organisms per cubic centimeter.]

|                                 | 1895.        |               |              |              |            |            |           |
|---------------------------------|--------------|---------------|--------------|--------------|------------|------------|-----------|
|                                 | June.        | Aug.          | Aug.         | Sept.        | Oct.       | Dec.       | Dec.      |
| <b>ANIMALS.</b>                 |              |               |              |              |            |            |           |
| <b>Infusoria, . . . . .</b>     | <b>1,214</b> | <b>156</b>    | <b>10</b>    | <b>45</b>    | <b>50</b>  | <b>0</b>   | <b>0</b>  |
| Codonella, . . . . .            | 0            | 0             | 0            | 8            | 0          | 0          | 0         |
| Dinobryon, . . . . .            | 894          | 153           | 0            | 0            | 0          | 0          | 0         |
| Dinobryon cases, . . . . .      | 320          | 0             | 0            | 5            | 0          | 0          | 0         |
| Euglena, . . . . .              | 0            | 0             | 0            | 0            | 7          | 0          | 0         |
| Peridinium, . . . . .           | 0            | 3             | 4            | 26           | 1          | 0          | 0         |
| Phacus, . . . . .               | 0            | 0             | 0            | 2            | 2          | 0          | 0         |
| Tintinnidium, . . . . .         | 0            | 0             | 0            | 1            | 0          | 0          | 0         |
| Trachelomonas, . . . . .        | 0            | 0             | 6            | 3            | 40         | 0          | 0         |
| <b>Vermes, . . . . .</b>        | <b>0</b>     | <b>0</b>      | <b>3</b>     | <b>14</b>    | <b>2</b>   | <b>0</b>   | <b>0</b>  |
| Anurea, . . . . .               | 0            | 0             | 1            | 14           | 2          | 0          | 0         |
| Rotifer, . . . . .              | 0            | 0             | 2            | 0            | 0          | 0          | 0         |
| <b>Miscellaneous, . . . . .</b> | <b>0</b>     | <b>0</b>      | <b>.04</b>   | <b>.08</b>   | <b>100</b> | <b>120</b> | <b>40</b> |
| Acarina, . . . . .              | 0            | 0             | .04          | .08          | 0          | 0          | 0         |
| Zoëglæa, . . . . .              | 0            | 0             | 0            | 0            | 100        | 120        | 40        |
| <b>TOTAL, . . . . .</b>         | <b>1,563</b> | <b>10,251</b> | <b>1,742</b> | <b>2,399</b> | <b>384</b> | <b>130</b> | <b>43</b> |

*Chemical Examination of Water from the Middle Storage Reservoir of the Northampton Water Works on Roberts' Meadow Brook, collected near the Bottom.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |               |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------------|---------------|--------|-------------------------|-------------------|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.        | Sediment.     | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |             |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                   |               |        |                         |                   |          | Total.      | Dissolved. | Sus-pended. |           |             |           |                  |           |
| 14761   | 1895.<br>Aug. 1     | Distinct.         | Cons., brown. | 2.50   | 8.00                    | 2.45              | .0520    | .0342       | .0242      | .0100       | .15       | .0050       | .0000     | 0.9438           | 3.4       |
| 14929   | Aug. 27             | V. slight.        | Cons., brown. | 3.30   | 8.50                    | 2.80              | .0232    | .0260       | .0188      | .0072       | .13       | .0000       | .0001     | 0.7800           | 2.3       |
| 15211   | Sept. 17            | Distinct.         | Slight.       | 3.30   | 8.35                    | 2.40              | .0156    | .0320       | .0216      | .0104       | .15       | .0030       | .0000     | 1.3850           | 2.7       |
| 15419   | Oct. 22             | Distinct.         | Cons., brown. | 0.90   | 5.05                    | 2.15              | .0038    | .0262       | .0210      | .0052       | .16       | .0100       | .0001     | 0.9672           | 1.3       |
| 15644   | Nov. 29             | Distinct.         | Slight.       | 0.70   | 4.10                    | 1.80              | .0004    | .0146       | .0122      | .0024       | .13       | .0020       | .0000     | 0.7176           | 1.3       |
| 15817   | Dec. 28             | Distinct, clayey. | Slight.       | 0.47   | 3.60                    | 1.25              | .0006    | .0156       | .0116      | .0040       | .12       | .0030       | .0000     | 0.5482           | 0.5       |
| Av.     | .....               | .....             | .....         | 1.86   | 6.27                    | 2.14              | .0159    | .0247       | .0182      | .0065       | .14       | .0038       | .0000     | 0.8870           | 2.0       |

Odor of the first three samples, offensive; of the others, vegetable. — Iron, No. 14761, .9750; No. 14929, .4000; No. 15211, .8600; No. 15419, .0480; No. 15644, not determined; No. 15817, .0230.

## NORTHAMPTON.

*Microscopical Examination of Water from the Middle Storage Reservoir of the Northampton Water Works on Roberts' Meadow Brook, collected near the Bottom.*

[Number of organisms per cubic centimeter.]

|                                   | 1895.        |              |            |            |           |           |
|-----------------------------------|--------------|--------------|------------|------------|-----------|-----------|
|                                   | Aug.         | Aug.         | Sept.      | Oct.       | Dec.      | Dec.      |
| Day of examination, . . . . .     | 6            | 30           | 25         | 25         | 2         | 31        |
| Number of sample, . . . . .       | 14761        | 14929        | 15211      | 15419      | 15644     | 15817     |
| <b>PLANTS.</b>                    |              |              |            |            |           |           |
| Diatomaceæ, . . . . .             | 498          | 783          | 8          | 232        | 14        | 5         |
| Cyclotella, . . . . .             | 496          | 780          | 2          | 228        | 0         | 0         |
| Diatoma, . . . . .                | 0            | 0            | 6          | 1          | 0         | 0         |
| Meridion, . . . . .               | 0            | 0            | 0          | 1          | 3         | 0         |
| Navicula, . . . . .               | 0            | 3            | 0          | 0          | 3         | 0         |
| Synedra, . . . . .                | 0            | 0            | 0          | 2          | 4         | 5         |
| Tabellaria, . . . . .             | 2            | 0            | 0          | 0          | 4         | 0         |
| Algae, . . . . .                  | 142          | 115          | 0          | 0          | 0         | 0         |
| Glæocapsa, . . . . .              | 128          | 0            | 0          | 0          | 0         | 0         |
| Protococcus, . . . . .            | 0            | 115          | 0          | 0          | 0         | 0         |
| Raphidium, . . . . .              | 14           | 0            | 0          | 0          | 0         | 0         |
| Fungi, Crenothrix, . . . . .      | 960          | 116          | 589        | 120        | 7         | 3         |
| <b>ANIMALS.</b>                   |              |              |            |            |           |           |
| Infusoria, . . . . .              | 24           | 5            | 10         | 48         | 0         | 0         |
| Dinobryon cases, . . . . .        | 24           | 1            | 0          | 0          | 0         | 0         |
| Monas, . . . . .                  | 0            | 1            | 0          | 0          | 0         | 0         |
| Trachelomonas, . . . . .          | 0            | 3            | 10         | 48         | 0         | 0         |
| Vermes, Anurea, . . . . .         | 0            | 1            | 0          | 1          | 0         | 0         |
| Miscellaneous, Zoëglia, . . . . . | 0            | 0            | 20         | 200        | 0         | 80        |
| <b>TOTAL, . . . . .</b>           | <b>1,624</b> | <b>1,020</b> | <b>598</b> | <b>601</b> | <b>21</b> | <b>88</b> |

*Chemical Examination of Water from the Lower Reservoir of the Northampton Water Works on Roberts' Meadow Brook.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 4453    | 1895.<br>June 10    | Distinct.   | Cons.     | .32    | 4.25                    | 1.45              | .0050    | .0204       | .0158      | .0046      | .09       | .0050       | .0000     | .5008            | 1.7       |

Odor, decidedly vegetable and unpleasant.

*Microscopical Examination.*

Diatomaceæ, *Cyclotella*, 1; *Fragilaria*, 16; *Melosira*, 2; *Tabellaria*, 8. Algae, *Protococcus*, 330. Fungi, *Crenothrix*, 2. Infusoria, *Dinobryon*, 1,280; *Dinobryon* cases, 900. Crustacea, *Cyclops*, .01. Miscellaneous, *Acarina*, .01. Total, 2,439.



## NORTH ATTLEBOROUGH.

## WATER SUPPLY OF NORTH ATTLEBOROUGH.

*Chemical Examination of Water from the Wells of the North Attleborough Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1895.</b>        |             |            |        |                         |          |             |           |             |           |                  |           |       |
| 14036   | Mar. 25             | None.       | V. slight. | .03    | 5.85                    | .0002    | .0012       | .63       | .0430       | .0000     | .0077            | 2.9       | .0050 |
| 14573   | July 1              | None.       | None.      | .00    | 6.60                    | .0002    | .0012       | .73       | .0400       | .0000     | .0213            | 2.6       | .0000 |
| 15420   | Oct. 23             | None.       | None.      | .00    | 7.80                    | .0008    | .0010       | .72       | .0550       | .0000     | .0429            | 3.1       | .0010 |
| 15747   | Dec. 16             | None.       | V. slight. | .00    | 6.20                    | .0000    | .0024       | .65       | .0430       | .0000     | .0216            | 2.9       | .0020 |
| Av.     | .....               | .....       | .....      | .01    | 6.61                    | .0003    | .0014       | .68       | .0452       | .0000     | .0234            | 2.9       | .0020 |

## Averages by Years.

|   |       |   |   |     |      |       |       |     |       |       |       |     |       |
|---|-------|---|---|-----|------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1887* | - | - | .00 | 6.28 | .0001 | .0011 | .50 | .0290 | -     | -     | -   | -     |
| - | 1888  | - | - | .00 | 6.27 | .0002 | .0013 | .50 | .0288 | .0000 | -     | -   | -     |
| - | 1889† | - | - | .00 | 6.09 | .0000 | .0012 | .55 | .0414 | .0000 | -     | -   | -     |
| - | 1892‡ | - | - | .00 | 5.95 | .0005 | .0015 | .53 | .0416 | .0000 | -     | -   | -     |
| - | 1893§ | - | - | .00 | 5.88 | .0003 | .0005 | .60 | .0450 | .0000 | .0109 | 2.8 | .0040 |
| - | 1894  | - | - | .04 | 6.84 | .0009 | .0010 | .70 | .0508 | .0001 | .0169 | 3.1 | .0175 |
| - | 1895  | - | - | .01 | 6.61 | .0003 | .0014 | .68 | .0452 | .0000 | .0234 | 2.9 | .0020 |

\* June to December. † January to May. ‡ April to December. § March and July.

NOTE to analyses of 1895: Odor, none. The following odors were developed on heating: first sample, none; second, distinct, peculiar; third, faintly acid; last, distinctly earthy. — The samples were collected from a faucet in the pumping station.

## Microscopical Examination.

No. 14036. Fungi, *Crenothrix*, 14. Miscellaneous, *Zoëglæa*, 40. Total, 54.

No organisms were found in the other samples.

## WATER SUPPLY OF NORTHBOROUGH.

*Chemical Examination of Water from the Upper Reservoir of the Northborough Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 15792   | 1895.<br>Dec. 23    | V. slight.  | Slight.   | .87    | 3.15                    | 1.35              | .0004    | .0200       | .0180      | .0020      | .11       | .0050       | .0000     | .7007            | 0.5       |

Odor, distinctly vegetable. — The sample was collected from the reservoir.

## Microscopical Examination.

Diatomaceæ, *Natricula*, 3; *Tabellaria*, 9. Miscellaneous, *Zoëglæa*, 5. Total, 17.

## NORTHBOROUGH.

*Chemical Examination of Water from the Lower Reservoir of the Northborough Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. |           |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. | Oxygen Consumed. | Hardness. |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 14190   | 1895.<br>Apr. 21    | Slight.     | Slight.    | .75    | 3.05                            | 1.45                 | .0000    | .0196       | .0180      | .0036           | .23       | .0000          | .0000     | .7110            | 0.8       |
| 14925   | Aug. 28             | Slight.     | Slight.    | .70    | 4.45                            | 2.05                 | .0000    | .0298       | .0246      | .0052           | .24       | .0030          | .0000     | .7956            | 0.9       |
| 15791   | Dec. 23             | V. slight.  | V. slight. | .65    | 3.35                            | 1.25                 | .0006    | .0160       | .0134      | .0026           | .13       | .0030          | .0000     | .6545            | 0.5       |
| Av.     | .....               | .....       | .....      | .70    | 3.62                            | 1.58                 | .0002    | .0218       | .0180      | .0038           | .20       | .0020          | .0000     | .7204            | 0.7       |

Odor of the first sample, very faintly vegetable, becoming stronger on heating; of the other samples, distinctly vegetable. — The samples were collected from the reservoir.

*Microscopical Examination.*

The number of organisms per cubic centimeter found in each of these samples was as follows: No. 14190, 123; No. 14925, 830; No. 15791, 6.

*Chemical Examination of Water from Faucets in Northborough supplied from the Northborough Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                  |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.        | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |                  |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 14191   | 1895.<br>Apr. 21    | V. slight.  | V. slight.       | .75    | 3.15                            | 1.65                 | .0000    | .0130       | .0118      | .0012           | .21       | .0050          | .0000     | .6754            | 0.9       |
| 14926   | Aug. 28             | Distinct.   | Cons.,<br>brown. | .75    | 4.70                            | 2.15                 | .0002    | .0298       | .0244      | .0054           | .27       | .0050          | .0003     | .7332            | 1.0       |

Odor of the first sample, very faintly vegetable; of the last, decidedly disagreeable.

*Microscopical Examination.*

The number of organisms per cubic centimeter found in each of these samples was as follows: No. 4191, 25; No. 14926, 360.

## NORTH BROOKFIELD.

## WATER SUPPLY OF NORTH BROOKFIELD.

*Chemical Examination of Water from Doane Pond, North Brookfield.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.       | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                 |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
|         | 1895.               |             |                 |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 13680   | Jan. 16             | V. slight.  | Slight.         | 0.40   | 7.45                    | 1.80              | .0238    | .0358       | .0274      | .0084      | .29       | .0230       | .0009     | .5056            | 3.1       |
| 13860   | Feb. 20             | Distinct.   | Cons.           | 0.80   | 7.50                    | 1.80              | .0338    | .0374       | .0296      | .0078      | .32       | .0150       | .0002     | .4524            | 2.7       |
| 14010   | Mar. 20             | Decided.    | Cons., green.   | 0.15   | 4.30                    | 1.00              | .0002    | .0494       | .0214      | .0280      | .20       | .0050       | .0001     | .3223            | 1.7       |
| 14166   | Apr. 17             | Distinct.   | Slight. clayey. | 0.20   | 4.20                    | 1.35              | .0086    | .0320       | .0254      | .0066      | .24       | .0180       | .0001     | .3357            | 1.6       |
| 14324   | May 20              | Distinct.   | Cons.           | 0.50   | 4.15                    | 1.10              | .0002    | .0420       | .0340      | .0080      | .21       | .0030       | .0001     | .4803            | 1.4       |
| 14494   | June 19             | Decided.    | Slight, yellow. | 0.50   | 3.95                    | 1.95              | .0018    | .0356       | .0272      | .0084      | .21       | .0050       | .0000     | .5772            | 1.3       |
| 14703   | July 24             | Distinct.   | Cons.           | 1.30   | 4.95                    | 2.35              | .0050    | .0462       | .0420      | .0042      | .26       | .0030       | .0000     | .8624            | 1.7       |
| 14891   | Aug. 21             | Decided.    | Cons., yellow.  | 0.95   | 4.55                    | 1.85              | .0004    | .0486       | .0384      | .0102      | .17       | .0000       | .0000     | .7410            | 1.6       |
| 15240   | Sept. 24            | Slight.     | Cons.           | 0.28   | 4.65                    | 1.40              | .0120    | .0268       | .0208      | .0060      | .24       | .0180       | .0007     | .3900            | 1.9       |
| 15401   | Oct. 21             | Distinct.   | Slight.         | 0.40   | 4.55                    | 1.65              | .0036    | .0412       | .0372      | .0040      | .19       | .0070       | .0001     | .5577            | 1.7       |
| 15585   | Nov. 20             | Slight.     | Slight.         | 0.30   | 4.45                    | 1.55              | .0010    | .0220       | .0206      | .0014      | .13       | .0080       | .0001     | .4368            | 1.1       |
| 15769   | Dec. 18             | Decided.    | Slight.         | 0.30   | 4.30                    | 1.40              | .0004    | .0212       | .0186      | .0026      | .13       | .0180       | .0001     | .4096            | 1.1       |
| Av.     | 1895                | .....       | .....           | 0.51   | 4.92                    | 1.60              | .0076    | .0365       | .0285      | .0080      | .22       | .0102       | .0002     | .5059            | 1.7       |
| Av.     | 1894                | .....       | .....           | 0.91   | 4.24                    | 1.77              | .0110    | .0353       | .0280      | .0073      | .19       | .0054       | .0001     | .6192            | 1.1       |

NOTE to analyses of 1895: Odor, generally distinctly vegetable, very rarely none; in December, faintly oily. — The samples were collected from the pond.

*Microscopical Examination of Water from Doane Pond, North Brookfield.*

[Number of organisms per cubic centimeter.]

|                           | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                           | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June  | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . | 17    | 22    | 20    | 18    | 21    | 20    | 26    | 22    | 26    | 23    | 21    | 19    |
| Number of sample, . . .   | 13680 | 13860 | 14010 | 14166 | 14324 | 14494 | 14703 | 14891 | 15240 | 15401 | 15585 | 15769 |
| PLANTS.                   |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .         | 2     | 0     | 0     | 40    | 383   | 369   | 1,133 | 354   | 0     | 268   | 144   | 4     |
| Asterionella, . . .       | pr.   | 0     | 0     | 2     | 65    | 171   | 11    | 32    | 0     | 140   | 44    | 4     |
| Cyclotella, . . .         | 0     | 0     | 0     | 3     | 1     | 0     | 0     | 9     | 0     | 0     | 0     | 0     |
| Fragilaria, . . .         | 0     | 0     | 0     | 5     | 0     | 6     | 2     | 0     | 0     | 0     | 0     | 0     |
| Navicula, . . .           | 0     | 0     | 0     | 2     | 7     | 1     | 0     | 1     | 0     | 4     | 0     | 0     |
| Synedra, . . .            | 2     | 0     | 0     | 7     | 284   | 14    | 0     | 0     | 0     | 28    | 44    | 0     |
| Tabellaria, . . .         | 0     | 0     | 0     | 21    | 26    | 177   | 1,120 | 312   | 0     | 96    | 56    | 0     |

## NORTH BROOKFIELD.

*Microscopical Examination of Water from Doane Pond, North Brookfield — Concluded.*

[Number of organisms per cubic centimeter.]

|                                  | 1895. |      |        |      |       |       |       |       |       |      |      |      |
|----------------------------------|-------|------|--------|------|-------|-------|-------|-------|-------|------|------|------|
|                                  | Jan.  | Feb. | Mar.   | Apr. | May.  | June. | July. | Aug.  | Sept. | Oct. | Nov. | Dec. |
| <b>PLANTS — Con.</b>             |       |      |        |      |       |       |       |       |       |      |      |      |
| <b>Cyanophyceæ, . . .</b>        | 0     | 0    | 0      | 0    | 15    | 0     | 1     | 9     | 0     | 5    | 0    | 0    |
| Chroococcus, . . .               | 0     | 0    | 0      | 0    | 15    | 0     | 0     | 4     | 0     | 0    | 0    | 0    |
| Microcystis, . . .               | 0     | 0    | 0      | 0    | 0     | 0     | 1     | 5     | 0     | 5    | 0    | 0    |
| <b>Algae, . . .</b>              | 0     | 0    | 0      | 1    | 453   | 59    | 1,117 | 4,982 | 4     | 230  | 15   | 0    |
| Arthrodesmus, . . .              | 0     | 0    | 0      | 0    | 0     | 7     | 5     | 78    | 0     | 2    | 0    | 0    |
| Chlorococcus, . . .              | 0     | 0    | 0      | 0    | 4     | 0     | 0     | 0     | 0     | 3    | 0    | 0    |
| Cosmarium, . . .                 | 0     | 0    | 0      | 0    | 0     | 0     | 4     | 6     | 0     | 0    | 0    | 0    |
| Gloeocapsa, . . .                | 0     | 0    | 0      | 0    | 2     | 0     | 4     | 11    | 0     | 0    | 0    | 0    |
| Pediastrum, . . .                | 0     | 0    | 0      | 0    | 2     | 0     | 1     | 70    | 0     | 0    | 0    | 0    |
| Protococcus, . . .               | 0     | 0    | 0      | 0    | 172   | 42    | 220   | 440   | 0     | 0    | 5    | 0    |
| Raphidium, . . .                 | 0     | 0    | 0      | 0    | 57    | 0     | 840   | 2,284 | 4     | 180  | 8    | 0    |
| Scenedesmus, . . .               | 0     | 0    | 0      | 1    | 168   | 1     | 3     | 16    | 0     | 7    | 1    | 0    |
| Staurostrum, . . .               | 0     | 0    | 0      | 0    | 32    | 9     | 40    | 2,052 | 0     | 24   | 1    | 0    |
| Staurogenia, . . .               | 0     | 0    | 0      | 0    | 16    | 0     | 0     | 7     | 0     | 14   | 0    | 0    |
| <b>Fungi, Crenothrix, . . .</b>  | 1     | 0    | 0      | 2    | 3     | 3     | 11    | 1     | 0     | 0    | 0    | 0    |
| <b>ANIMALS.</b>                  |       |      |        |      |       |       |       |       |       |      |      |      |
| <b>Infusoria, . . .</b>          | 1     | 61   | 15,567 | 28   | 950   | 228   | 9     | 836   | 15    | 90   | 34   | 381  |
| Cryptomonas, . . .               | 0     | 0    | 100    | 0    | 0     | 0     | 0     | 0     | 0     | 0    | 0    | 0    |
| Dinobryon, . . .                 | 0     | 0    | 5      | 6    | 348   | 228   | 0     | 28    | 0     | 38   | 21   | 376  |
| Dinobryon cases, . . .           | 0     | 0    | 0      | 0    | 600   | 0     | 0     | 748   | 0     | 52   | 3    | 0    |
| Euchelys, . . .                  | 0     | 0    | 0      | 0    | 0     | 0     | 0     | 40    | 0     | 0    | 0    | 0    |
| Euglena, . . .                   | 1     | 13   | 60     | 14   | 0     | 0     | 0     | 0     | 0     | 0    | 0    | 0    |
| Monas, . . .                     | 0     | 0    | 2      | 0    | 0     | 0     | 0     | 5     | 0     | 0    | 0    | 0    |
| Peridinium, . . .                | 0     | 48   | 15,400 | 8    | 1     | 0     | 4     | 8     | 0     | 0    | 3    | 0    |
| Trachelomonas, . . .             | 0     | 0    | 0      | 0    | 1     | 0     | 5     | 7     | 15    | 0    | 0    | 0    |
| Uroglena, . . .                  | 0     | 0    | 0      | 0    | 0     | 0     | 0     | 0     | 0     | 0    | 7    | 5    |
| <b>Vermes, . . .</b>             | 0     | 0    | 0      | 2    | 2     | 2     | 1     | 1     | 1     | 0    | 0    | 0    |
| Anurea, . . .                    | 0     | 0    | 0      | 0    | 0     | 2     | 1     | 0     | 1     | 0    | 0    | 0    |
| Polyarthra, . . .                | 0     | 0    | 0      | 1    | 1     | 0     | 0     | 0     | 0     | 0    | 0    | 0    |
| Rotatorian ova, . . .            | 0     | 0    | 0      | 1    | 1     | 0     | 0     | 1     | 0     | 0    | 0    | 0    |
| <b>Crustacea, Daphnia, . . .</b> | 0     | 0    | 0      | 0    | 0     | 0     | .02   | 0     | .08   | 0    | 0    | 0    |
| <b>Miscellaneous, . . .</b>      |       |      |        |      |       |       |       |       |       |      |      |      |
| Acarina, . . .                   | 0     | 0    | 0      | 0    | 0     | 0     | 0     | .06   | .02   | .04  | 0    | 0    |
| Zoöglæa, . . .                   | 0     | 340  | 540    | 312  | 332   | 0     | 0     | 88    | 160   | 200  | 20   | 0    |
| <b>TOTAL, . . .</b>              | 4     | 401  | 16,107 | 385  | 2,138 | 661   | 2,272 | 6,251 | 180   | 793  | 213  | 385  |

**NORTH BROOKFIELD.****Chemical Examination of Water from the Filled-water Well of the North Brookfield Water Works.**

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |               |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------------|---------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.        | Sediment.     | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                   |               |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13681   | 1895. Jan. 16       | V. slight.        | Slight.       | 0.23   | 6.40                    | 1.20              | .0406    | .0362       | .0270      | .0092      | .27       | .0150       | .0000     | .4230            | 2.7       |
| 13861   | Feb. 20             | Slight.           | V. slight.    | 0.02   | 8.75                    | 1.10              | .0560    | .0170       | .0112      | .0055      | .20       | .0100       | .0001     | .1342            | 3.6       |
| 14011   | Mar. 20             | Decided.          | Slight.       | 0.02   | 8.40                    | 1.40              | .0402    | .0202       | .0114      | .0088      | .24       | .0120       | .0002     | .1540            | 3.6       |
| 14167   | Apr. 17             | Distinct, clayey. | Slight.       | 0.23   | 4.00                    | 1.10              | .0042    | .0188       | .0138      | .0050      | .22       | .0150       | .0001     | .2891            | 1.6       |
| 14325   | May 20              | Distinct.         | Slight.       | 0.50   | 3.85                    | 1.05              | .0000    | .0292       | .0222      | .0070      | .22       | .0030       | .0000     | .4677            | 1.6       |
| 14495   | June 19             | Slight, milky.    | V. slight.    | 0.12   | 5.30                    | 2.55              | .0008    | .0132       | .0112      | .0020      | .20       | .0170       | .0004     | .1677            | 1.7       |
| 14704   | July 24             | Distinct.         | Cons., rusty. | 1.10   | 5.15                    | 2.15              | .0152    | .0424       | .0292      | .0132      | .24       | .0030       | .0000     | .7409            | 1.7       |
| 14892   | Aug. 21             | Slight.           | Slight.       | 0.90   | 4.20                    | 2.30              | .0004    | .0328       | .0254      | .0074      | .20       | .0000       | .0000     | .5538            | 1.1       |
| 15241   | Sept. 24            | Distinct.         | Cons.         | 0.40   | 4.30                    | 1.80              | .0022    | .0386       | .0336      | .0050      | .24       | .0090       | .0000     | .5476            | 1.4       |
| 15402   | Oct. 21             | Distinct.         | Slight.       | 0.30   | 4.00                    | 1.15              | .0026    | .0252       | .0216      | .0036      | .19       | .0130       | .0000     | .4407            | 1.7       |
| 15586   | Nov. 20             | Slight.           | Slight.       | 0.30   | 4.60                    | 1.50              | .0006    | .0214       | .0192      | .0022      | .16       | .0070       | .0001     | .3939            | 1.4       |
| 15770   | Dec. 18             | Slight, clayey.   | Slight.       | 0.33   | 2.65                    | 0.65              | .0012    | .0114       | .0096      | .0018      | .16       | .0030       | .0001     | .1309            | 1.1       |
| Av.     | 1895                | .....             | .....         | 0.37   | 5.13                    | 1.50              | .0137    | .0255       | .0196      | .0059      | .21       | .0089       | .0001     | .3710            | 1.9       |
| Av.     | 1894                | .....             | .....         | 0.73   | 4.68                    | 1.86              | .0096    | .0286       | .0252      | .0034      | .19       | .0095       | .0002     | .5427            | 1.6       |

NOTE to analyses of 1895: Odor, generally distinctly vegetable, often also unpleasant; very rarely none.— The samples were collected from the filtered-water well.

**Microscopical Examination of Water from the Filled-water Well of the North Brookfield Water Works.**

[Number of organisms per cubic centimeter.]

|                           | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                           | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . | 17    | 22    | 21    | 18    | 21    | 20    | 26    | 22    | 26    | 23    | 21    | 20    |
| Number of sample, . . .   | 13681 | 13861 | 14011 | 14167 | 14325 | 14495 | 14704 | 14892 | 15241 | 15402 | 15586 | 15770 |
| PLANTS.                   |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .         | 2     | 1     | 0     | 19    | 235   | pr.   | 650   | 16    | 672   | 46    | 3     | 0     |
| Asterionella, . . .       | 2     | 0     | 0     | 0     | 31    | 0     | 0     | 8     | 12    | 17    | 2     | 0     |
| Synedra, . . .            | 0     | 1     | 0     | 2     | 188   | pr.   | 2     | pr.   | 432   | 20    | 1     | 0     |
| Tabellaria, . . .         | 0     | 0     | 0     | 17    | 16    | 0     | 648   | 8     | 228   | 9     | 0     | 0     |

## NORTH BROOKFIELD.

## Microscopical Examination of Water from the Filled-water Well of the North Brookfield Water Works—Concluded.

[Number of organisms per cubic centimeter.]

|                            | 1895. |      |       |      |       |       |       |       |       |      |      |      |
|----------------------------|-------|------|-------|------|-------|-------|-------|-------|-------|------|------|------|
|                            | Jan.  | Feb. | Mar.  | Apr. | May.  | June. | July. | Aug.  | Sept. | Oct. | Nov. | Dec. |
| <b>PLANTS—Con.</b>         |       |      |       |      |       |       |       |       |       |      |      |      |
| Algae, . . . . .           | 0     | 0    | 0     | 20   | 495   | pr.   | 2,838 | 1,586 | 177   | 98   | 0    | 0    |
| Arthrodesmus, . . . . .    | 0     | 0    | 0     | 0    | 2     | 0     | 0     | 12    | 0     | 5    | 0    | 0    |
| Closterium, . . . . .      | 0     | 0    | 0     | 0    | 2     | 0     | 0     | 0     | 4     | 1    | 0    | 0    |
| Cosmarium, . . . . .       | 0     | 0    | 0     | 0    | 0     | 0     | 12    | 1     | 2     | 0    | 0    | 0    |
| Glaucocapsa, . . . . .     | 0     | 0    | 0     | 0    | 1     | 0     | 2,400 | 2     | 0     | 0    | 0    | 0    |
| Protococcus, . . . . .     | 0     | 0    | 0     | 20   | 380   | 0     | 72    | 114   | 9     | 0    | 0    | 0    |
| Raphidium, . . . . .       | 0     | 0    | 0     | 0    | 4     | 0     | 320   | 604   | 64    | 80   | 0    | 0    |
| Scenedesmus, . . . . .     | 0     | 0    | 0     | 0    | 68    | pr.   | 6     | 12    | 7     | 1    | 0    | 0    |
| Selenastrum, . . . . .     | 0     | 0    | 0     | 0    | 0     | 0     | 0     | 0     | 7     | 0    | 0    | 0    |
| Staurostrum, . . . . .     | 0     | 0    | 0     | 0    | 32    | 0     | 26    | 838   | 76    | 7    | 0    | 0    |
| Staurogenia, . . . . .     | 0     | 0    | 0     | 0    | 6     | 0     | 2     | 3     | 8     | 4    | 0    | 0    |
| Fungi, Crenothrix, . . . . | 2     | 0    | 0     | 7    | 2     | 0     | 212   | 0     | 0     | 1    | 44   | 3    |
| <b>ANIMALS.</b>            |       |      |       |      |       |       |       |       |       |      |      |      |
| Infusoria, . . . . .       | 8     | 12   | 130   | 15   | 1,152 | 0     | 112   | 189   | 103   | 50   | 0    | 0    |
| Dinobryon, . . . . .       | 2     | 0    | 0     | 0    | 416   | 0     | 0     | 36    | 12    | 6    | 0    | 0    |
| Dinobryon cases, . . . .   | 0     | 0    | 0     | 0    | 736   | 0     | 0     | 136   | 88    | 40   | 0    | 0    |
| Enchelys, . . . . .        | 0     | 0    | 0     | 0    | 0     | 0     | 0     | 10    | 0     | 0    | 0    | 0    |
| Euglena, . . . . .         | 3     | 0    | 96    | 11   | 0     | 0     | 0     | 0     | 0     | 0    | 0    | 0    |
| Monas, . . . . .           | 1     | 0    | 2     | 0    | 0     | 0     | 2     | 1     | 0     | 1    | 0    | 0    |
| Peridinium, . . . . .      | 2     | 12   | 32    | 2    | 0     | 0     | 2     | 3     | 0     | 1    | 0    | 0    |
| Tintinnidium, . . . . .    | 0     | 0    | 0     | 0    | 0     | 0     | 4     | 0     | 0     | 0    | 0    | 0    |
| Trachelomonas, . . . . .   | 0     | 0    | 0     | 2    | 0     | 0     | 104   | 3     | 3     | 2    | 0    | 0    |
| Vermes, . . . . .          | pr.   | 0    | 0     | 0    | 9     | 0     | 4     | 0     | 1     | 0    | 0    | 0    |
| Anurea, . . . . .          | 0     | 0    | 0     | 0    | 3     | 0     | 2     | 0     | 0     | 0    | 0    | 0    |
| Polyarthra, . . . . .      | 0     | 0    | 0     | 0    | 3     | 0     | 0     | 0     | 0     | 0    | 0    | 0    |
| Rotatorian ova, . . . . .  | 0     | 0    | 0     | 0    | 3     | 0     | 0     | 0     | 1     | 0    | 0    | 0    |
| Rotifer, . . . . .         | pr.   | 0    | 0     | 0    | 0     | 0     | 2     | 0     | 0     | 0    | 0    | 0    |
| Miscellaneous, . . . . .   | 660   | 800  | 2,480 | 136  | 0     | 0     | 0     | 106   | 236   | 60   | 160  | 0    |
| Acarina, . . . . .         | 0     | 0    | 0     | 0    | 0     | 0     | 0     | 0     | 12    | 0    | 0    | 0    |
| Zoöglæa, . . . . .         | 660   | 800  | 2,480 | 136  | 0     | 0     | 0     | 106   | 236   | 60   | 160  | 0    |
| TOTAL, . . . . .           | 672   | 813  | 2,610 | 167  | 1,893 | pr.   | 3,816 | 1,897 | 1,189 | 255  | 207  | 3    |

## NORTON.

## NORTON.

*Chemical Examination of Water from a Tributary of the Wading River in the Westerly Part of Norton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA.    |        |            |                | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|-------------|--------|------------|----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Albuminoid. |        |            |                |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      | Free.       | Total. | Dissolved. | Sus-<br>pended |           |                |           |                  |           |
| 15432   | 1895.<br>Oct. 25    | None.       | V. slight. | 2.00   | 9.80*                           | 5.20                 | .0074       | .0486  | -          | -              | .53       | .0050          | .0000     | 3.0264           | 2.5       |

\* Unfiltered.

Odor, none, becoming distinctly vegetable on heating. — The sample was collected from a filter-well in a brook near the factory of A. H. Sweet, in the vicinity of Main Street.

*Microscopical Examination.*

Algae, *Raphidium*, 1. Fungi, *Molds*, 1. Vermes, *Rotifer*, 1. Miscellaneous, *Zoöglæa*, 72. Total, 75.

## WATER SUPPLY OF NORWOOD.

The organism *Uroglæna* reappeared in the water of Buckmaster Pond in October, 1895, and increased rapidly in numbers during the remainder of the year. The taste and odor of the water became very disagreeable, and the water continued to give serious trouble from this cause in the early part of 1896.

*Chemical Examination of Water from Brooks flowing into Buckmaster Pond, Dedham.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA.    |        |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|-------------|--------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Albuminoid. |        |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      | Free.       | Total. | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 15596   | 1895.<br>Nov. 20    | V. slight.  | V. slight. | 0.40   | 3.40                            | 1.50                 | .0000       | .0100  | .0084      | .0016           | .86       | .0030          | .0001     | 0.5132           | 0.5       |
| 15597   | Nov. 20             | V. slight.  | V. slight. | 1.00   | 4.30                            | 2.35                 | .0000       | .0130  | .0118      | .0012           | .25       | .0000          | .0001     | 1.0803           | 0.5       |

Odor, distinctly vegetable, becoming less strong on heating. — The first sample was collected from a small brook flowing into the north-westerly side of the pond, and the last from a brook flowing into the north-easterly side of the pond.

*Microscopical Examination.*

No. 15596. Diatomaceæ, *Diatoma*, 4; *Melosira*, 10; *Navicula*, 4. Miscellaneous, *Zoöglæa*, 4. Total, 22.

No. 15597. Diatomaceæ, *Diatoma*, 2; *Meridion*, 1; *Navicula*, 4. Miscellaneous, *Zoöglæa*, 10. Total, 17.

NORWOOD.

*Chemical Examination of Water from Buckmaster Pond, Dedham.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13600   | 1895.<br>Jan. 3     | V. slight.  | V. slight.     | .07    | 3.20                    | 1.15              | .0182    | .0210       | .0174      | .0036      | .36       | .0030       | .0000     | .1809            | 1.1       |
| 13772   | Feb. 5              | V. slight.  | V. slight.     | .40    | 2.90                    | 0.90              | .0028    | .0186       | .0140      | .0046      | .30       | .0150       | .0000     | .3673            | 0.6       |
| 13933   | Mar. 5              | Slight.     | Cons.          | .10    | 3.05                    | 1.00              | .0054    | .0262       | .0144      | .0118      | .35       | .0080       | .0000     | .2233            | 0.8       |
| 14088   | Apr. 2              | Slight.     | Slight.        | .12    | 2.90                    | 0.95              | .0092    | .0178       | .0150      | .0028      | .35       | .0090       | .0000     | .2680            | 0.8       |
| 14260   | May 7               | Slight.     | Slight.        | .18    | 2.90                    | 1.25              | .0006    | .0164       | .0146      | .0018      | .35       | .0000       | .0000     | .2934            | 0.5       |
| 14416   | June 4              | Slight.     | Slight.        | .20    | 2.60                    | 1.20              | .0000    | .0184       | .0164      | .0020      | .36       | .0050       | .0000     | .3519            | 0.5       |
| 14597   | July 9              | Distinct.   | Slight.        | .15    | 3.60                    | 2.20              | .0000    | .0206       | .0188      | .0018      | .37       | .0030       | .0000     | .3199            | 0.3       |
| 14777   | Aug. 6              | Distinct.   | Slight.        | .10    | 2.60                    | 1.75              | .0012    | .0212       | .0182      | .0030      | .40       | .0180       | .0000     | .3198            | 0.8       |
| 14903   | Sept. 2             | Slight.     | Cons., yellow. | .12    | 2.85                    | 1.15              | .0000    | .0232       | .0194      | .0038      | .41       | .0020       | .0001     | .3041            | 0.2       |
| 15309   | Oct. 2              | Distinct.   | Slight, green. | .12    | 2.65                    | 1.15              | .0010    | .0302       | .0236      | .0066      | .40       | .0030       | .0000     | .2714            | 0.3       |
| 15480   | Nov. 5              | Decided.    | Slight.        | .12    | 2.90                    | 1.10              | .0074    | .0244       | .0194      | .0050      | .37       | .0100       | .0000     | .2792            | 0.5       |
| 15667   | Dec. 3              | Decided.    | Slight.        | .20    | 3.30                    | 1.05              | .0106    | .0262       | .0180      | .0082      | .33       | .0030       | .0001     | .2980            | 0.6       |
| Av.     | .....               | .....       | .....          | .16    | 2.95                    | 1.24              | .0047    | .0220       | .0174      | .0046      | .36       | .0066       | .0000     | .2898            | 0.5       |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | .09 | 2.64 | 1.06 | .0058 | .0212 | -     | -     | .30 | .0018 | -     | -     | -   |
| - | 1888  | - | - | .15 | 2.66 | 0.95 | .0069 | .0248 | -     | -     | .29 | .0065 | .0001 | -     | -   |
| - | 1889  | - | - | .11 | 2.43 | 0.78 | .0025 | .0196 | .0172 | .0024 | .30 | .0070 | .0001 | -     | -   |
| - | 1890  | - | - | .05 | 2.59 | 0.99 | .0015 | .0180 | .0147 | .0033 | .30 | .0075 | .0000 | -     | 1.0 |
| - | 1891  | - | - | .06 | 2.43 | 0.97 | .0014 | .0166 | .0140 | .0026 | .26 | .0075 | .0000 | -     | 0.7 |
| - | 1892  | - | - | .07 | 2.88 | 1.24 | .0019 | .0219 | .0172 | .0047 | .32 | .0067 | .0000 | -     | 0.7 |
| - | 1893  | - | - | .07 | 2.62 | 1.08 | .0052 | .0199 | .0156 | .0043 | .33 | .0028 | .0000 | .2544 | 0.7 |
| - | 1894  | - | - | .10 | 2.82 | 1.13 | .0055 | .0182 | .0153 | .0029 | .36 | .0028 | .0000 | .2373 | 0.5 |
| - | 1895  | - | - | .16 | 2.95 | 1.24 | .0047 | .0220 | .0174 | .0046 | .36 | .0066 | .0000 | .2898 | 0.5 |

\* June to December.

**NOTE** to analyses of 1896: Odor, frequently vegetable and unpleasant, sometimes none; in November and December, faintly oily, becoming stronger on heating. There was also an oily odor in the March sample on heating. — The samples were collected from the pond.



## NORWOOD.

*Microscopical Examination of Water from Buckmaster Pond, Dedham.*

[Number of organisms per cubic centimeter.]

|                                   | 1895. |       |        |       |       |       |       |       |       |       |       |       |
|-----------------------------------|-------|-------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                   | Jan.  | Feb.  | Mar.   | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . . .     | 5     | 7     | 8      | 4     | 8     | 5     | 11    | 8     | 6     | 4     | 6     | 4     |
| Number of sample, . . . . .       | 13600 | 13772 | 13933  | 14088 | 14260 | 14416 | 14597 | 14777 | 14963 | 15309 | 15480 | 15667 |
| <b>PLANTS.</b>                    |       |       |        |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . . .             | 452   | 1     | 0      | 215   | 142   | 248   | 20    | 3     | 7     | 4     | 49    | 501   |
| Asterionella, . . . . .           | 47    | 0     | 0      | 208   | 136   | 8     | 0     | 0     | 0     | 0     | 30    | 472   |
| Cyclotella, . . . . .             | 5     | 0     | 0      | 1     | 2     | 169   | 16    | 2     | 1     | 0     | 0     | 6     |
| Melosira, . . . . .               | 20    | 0     | 0      | 4     | 0     | 6     | 0     | 0     | 0     | 3     | 0     | 3     |
| Navicula, . . . . .               | 0     | 0     | 0      | 2     | 0     | 1     | 0     | 1     | 0     | 0     | 4     | 2     |
| Stephanodiscus, . . . . .         | 0     | 0     | 0      | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 7     | 0     |
| Synedra, . . . . .                | 350   | 1     | 0      | 0     | 2     | 15    | 4     | 0     | 2     | 1     | 8     | 8     |
| Tabellaria, . . . . .             | 0     | 0     | 0      | 0     | 2     | 49    | 0     | 0     | 4     | 0     | 0     | 10    |
| Cyanophyceæ, Microcystis, .       | 0     | 0     | 0      | 0     | 0     | 0     | 3     | 2     | 16    | 46    | 24    | 0     |
| Algeæ, . . . . .                  | 0     | 6     | 0      | 0     | 32    | 36    | 121   | 117   | 310   | 43    | 0     | 64    |
| Arthrodesmus, . . . . .           | 0     | 0     | 0      | 0     | 3     | 2     | 2     | 1     | 0     | 0     | 0     | 0     |
| Protococcus, . . . . .            | 0     | 6     | 0      | 0     | 25    | 34    | 93    | 107   | 300   | 32    | 0     | 0     |
| Raphidium, . . . . .              | 0     | 0     | 0      | 0     | 4     | 0     | 26    | 9     | 10    | 3     | 0     | 0     |
| Staurogenia, . . . . .            | 0     | 0     | 0      | 0     | 0     | 0     | 0     | 0     | 0     | 8     | 0     | 0     |
| Ulothrix, . . . . .               | 0     | 0     | 0      | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 64    |
| Fungi, Crenothrix, . . . . .      | 0     | 0     | 0      | 5     | 1     | 0     | 0     | 1     | 0     | 0     | 0     | 0     |
| <b>ANIMALS.</b>                   |       |       |        |       |       |       |       |       |       |       |       |       |
| Rhizopoda, Arcella, . . . . .     | 0     | 0     | 0      | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     |
| Infusoria, . . . . .              | 3     | 104   | 68,008 | 515   | 98    | 30    | 4     | 112   | 1     | 11    | 129   | 56    |
| Cryptomonas, . . . . .            | 0     | 0     | 0      | 100   | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     |
| Dinobryon, . . . . .              | 0     | 20    | 68,000 | 260   | 0     | 5     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, . . . . .        | 3     | 76    | 0      | 152   | 96    | 0     | 0     | 0     | 0     | 0     | 104   | 24    |
| Euglena, . . . . .                | 0     | 2     | 0      | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Mallomonas, . . . . .             | 0     | 0     | 0      | 1     | 0     | 25    | 0     | 0     | 0     | 0     | 0     | 0     |
| Peridinium, . . . . .             | 0     | 6     | 4      | 0     | 2     | 0     | 4     | 112   | 0     | 0     | 0     | 1     |
| Trachelomonas, . . . . .          | 0     | 0     | 4      | 2     | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 0     |
| Uroglena, . . . . .               | 0     | 0     | 0      | 0     | 0     | 0     | 0     | 0     | 0     | 11    | 25    | 30    |
| Miscellaneous, Zoöglæa, . . . . . | 0     | 0     | 0      | 0     | 6     | 0     | 0     | 0     | 6     | 0     | 0     | 20    |
| TOTAL, . . . . .                  | 455   | 111   | 68,008 | 735   | 279   | 314   | 148   | 235   | 340   | 104   | 204   | 641   |

Table showing Heights of Water in Buckmaster Pond on the First of Each Month in 1895.

[Distance below crest of dam.]

| DATE.—1895.        | Feet. | DATE.—1895.        | Feet. |
|--------------------|-------|--------------------|-------|
| Jan. 1, . . . . .  | 3.58  | July 1, . . . . .  | 1.67  |
| Feb. 1, . . . . .  | 1.25  | Aug. 1, . . . . .  | 2.58  |
| March 1, . . . . . | 1.42  | Sept. 1, . . . . . | 3.83  |
| April 1, . . . . . | 0.38  | Oct. 1, . . . . .  | 5.67  |
| May 1, . . . . .   | 0.02  | Nov. 1, . . . . .  | 4.58  |
| June 1, . . . . .  | 0.60  | Dec. 1, . . . . .  | 1.42  |

## ORANGE.

## WATER SUPPLY OF ORANGE.

During 1895 a reservoir was constructed near the pumping station of the Orange water works for the purpose of collecting the water of a spring for use in supplying the town. The reservoir is oval in shape, 130 feet long, 75 feet wide and 10 feet deep, and when filled to the level of the overflow has a capacity of 600,000 gallons. The inside slopes of the basin are paved with field stones.

The organism *Uroglena* was found in considerable numbers in samples from the distributing reservoir collected in May and October. Examinations made in the early part of 1896 showed the presence of *Uroglena* in North Pond, one of the sources of supply of the town.

*Chemical Examination of Water from North Pond, Orange.*

[Parts per 100,000.]

| number. | Date of Collection. | APPEARANCE.         |                      |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|----------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment.            | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                     |                      |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 24      | 1895.<br>Jan. 16    | Slight.             | Slight.              | 0.88   | 3.45                            | 1.70                 | .0084    | .0210       | .0200      | .0010           | .14       | .0030          | .0000     | 0.5964           | 0.9       |
| 17      | Feb. 20             | V. slight.          | Slight.              | 0.80   | 3.65                            | 1.60                 | .0062    | .0246       | .0202      | .0044           | .06       | .0050          | .0000     | 0.6747           | 0.9       |
| 7       | Mar. 20             | V. slight.          | Slight.              | 0.12   | 2.30                            | 0.95                 | .0018    | .0244       | .0208      | .0036           | .15       | .0070          | .0000     | 0.2646           | 0.3       |
|         | Apr. 17             | None.               | white.<br>V. slight. | 0.25   | 2.50                            | 1.00                 | .0000    | .0060       | .0052      | .0008           | .16       | .0030          | .0000     | 0.3571           | 0.6       |
|         | May 20              | Distinct.           | Cons.                | 0.58   | 2.95                            | 1.45                 | .0000    | .0232       | .0178      | .0054           | .11       | .0000          | .0000     | 0.6004           | 0.9       |
|         | June 19             | Decided.            | Cons.,<br>yellow.    | 0.93   | 3.30                            | 2.25                 | .0012    | .0378       | .0332      | .0046           | .13       | .0050          | .0001     | 0.9048           | 0.6       |
|         | July 23             | Slight.             | Slight.              | 1.20   | 3.90                            | 2.65                 | .0000    | .0370       | .0342      | .0028           | .21       | .0000          | .0000     | 1.0350           | 0.9       |
|         | Aug. 21             | Distinct,<br>green. | Slight.              | 1.20   | 3.70                            | 2.55                 | .0020    | .0394       | .0372      | .0022           | .16       | .0000          | .0000     | 1.2000           | 0.5       |
|         | Sept. 19            | Decided,<br>green.  | Slight,<br>brown.    | 0.68   | 3.45                            | 1.65                 | .0023    | .0314       | .0222      | .0092           | .16       | .0030          | .0000     | 0.7020           | 0.9       |
|         | Oct. 24             | Distinct,<br>green. | Slight,<br>brown.    | 0.98   | 3.45                            | 1.85                 | .0064    | .0320       | .0288      | .0032           | .16       | .0030          | .0000     | 0.7917           | 0.8       |
|         | Nov. 21             | Slight.             | Slight.              | 0.70   | 3.80                            | 1.75                 | .0022    | .0152       | .0120      | .0032           | .11       | .0030          | .0000     | 0.7582           | 0.6       |
|         | Dec. 18             | V. slight.          | V. slight.           | 0.33   | 3.20                            | 1.20                 | .0004    | .0124       | .0110      | .0014           | .12       | .0070          | .0001     | 0.4158           | 0.5       |
|         | 1895                | .....               | .....                | 0.72   | 3.30                            | 1.72                 | .0026    | .0254       | .0219      | .0035           | .14       | .0032          | .0000     | 0.6925           | 0.7       |
|         | 1896                | .....               | .....                | 0.67   | 3.38                            | 1.63                 | .0012    | .0229       | .0194      | .0035           | .13       | .0019          | .0000     | 0.5964           | 0.9       |

to analyses of 1895: Odor, vegetable, and sometimes unpleasant. — The samples were from the pond.

## ORANGE.

*Microscopical Examination of Water from North Pond, Orange.*

[Number of organisms per cubic centimeter.]

|                                 | 1893. |       |       |       |       |       |       |       |       |       |       |       |
|---------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                 | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .       | 17    | 23    | 21    | 18    | 21    | 20    | 25    | 23    | 21    | 25    | 22    | 20    |
| Number of sample, . . .         | 13684 | 13867 | 14017 | 14177 | 14329 | 14504 | 14694 | 14896 | 15223 | 15427 | 15592 | 15774 |
| PLANTS.                         |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . .             | 26    | 4     | 1     | 2     | 1,365 | 510   | 56    | 112   | 10    | 128   | 13    | 4     |
| Asterionella, . . . .           | 14    | 4     | 0     | 0     | 202   | 452   | 51    | 41    | 0     | 62    | 1     | 0     |
| Cyclotella, . . . .             | 0     | 0     | 0     | 0     | 0     | 9     | 0     | 8     | 0     | 0     | 0     | 0     |
| Melosira, . . . .               | 0     | 0     | 0     | 0     | 45    | 0     | 0     | 48    | 2     | 53    | 8     | 0     |
| Meridion, . . . .               | 3     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 3     |
| Synedra, . . . .                | pr.   | 0     | 1     | 0     | 332   | 9     | 3     | 3     | 0     | 9     | 4     | 1     |
| Tabellaria, . . . .             | 9     | 0     | 0     | 0     | 696   | 40    | 2     | 12    | 7     | 4     | 0     | 0     |
| Cyanophyceæ, . . . .            | 0     | 0     | 0     | 0     | 4     | 0     | 0     | 1     | 15    | 1     | 8     | 0     |
| Anabæna, . . . .                | 0     | 0     | 0     | 0     | 4     | 0     | 0     | 0     | 0     | 0     | 7     | 0     |
| Clathrocystis, . . . .          | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 15    | 1     | 1     | 0     |
| Algæ, . . . .                   | 0     | 0     | 1     | 0     | 65    | 37    | 281   | 367   | 57    | 8     | 1     | 1     |
| Arthrodesmus, . . . .           | 0     | 0     | 0     | 0     | 0     | 1     | 5     | 2     | 0     | 0     | 0     | 0     |
| Chlorococcus, . . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 316   | 0     | 0     | 0     | 0     |
| Conferva, . . . .               | 0     | 0     | 0     | 0     | 0     | 4     | 2     | 9     | 0     | 2     | 0     | 0     |
| Gleocapsa, . . . .              | 0     | 0     | 0     | 0     | 0     | 5     | 16    | 20    | 2     | 0     | 0     | 0     |
| Protococcus, . . . .            | 0     | 0     | 1     | 0     | 60    | 22    | 244   | 3     | 15    | 0     | 0     | 0     |
| Raphidium, . . . .              | 0     | 0     | 0     | 0     | 2     | 0     | 11    | 2     | 14    | 2     | 0     | 1     |
| Scenedesmus, . . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 9     | 0     | 1     | 0     | 0     |
| Selenastrum, . . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 15    | 0     | 0     | 0     |
| Staurastrum, . . . .            | 0     | 0     | 0     | 0     | 3     | 5     | 3     | 1     | 1     | 1     | 1     | 0     |
| Staurigenia, . . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 5     | 10    | 0     | 0     | 0     |
| Fungi, Crenothrix, . . . .      | 0     | 0     | 1     | 1     | 7     | 48    | 68    | 3     | 19    | 2     | 1     | 0     |
| ANIMALS.                        |       |       |       |       |       |       |       |       |       |       |       |       |
| Rhizopoda, Actinophrys, . . . . | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 24    | 0     | 0     | 0     | 0     |
| Infusoria, . . . .              | pr.   | 34    | 1     | 1     | 771   | 45    | 18    | 23    | 7     | 3     | 0     | 3     |
| Dinobryon, . . . .              | 0     | 0     | 0     | 0     | 0     | 29    | 0     | 0     | 0     | 0     | 0     | 3     |
| Dinobryon cases, . . . .        | 0     | 0     | 0     | 0     | 768   | 16    | 0     | 0     | 0     | 0     | 0     | 0     |
| Mallomonas, . . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     |
| Monas, . . . .                  | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 3     | 0     | 0     | 0     | 0     |
| Peridinium, . . . .             | pr.   | 33    | 1     | 1     | 1     | 0     | 7     | 19    | 0     | 0     | 0     | 0     |
| Synura, . . . .                 | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Trachelomonas, . . . .          | 0     | 1     | 0     | 0     | 0     | 0     | 9     | 1     | 7     | 3     | 0     | 0     |
| Vermes, . . . .                 | 0     | 1     | 0     | 0     | 6     | 5     | 4     | 3     | 0     | 1     | 0     | 0     |
| Anurea, . . . .                 | 0     | 0     | 0     | 0     | 1     | 5     | 0     | 0     | 0     | 1     | 0     | 0     |
| Polyarthra, . . . .             | 0     | 0     | 0     | 0     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Rotatorian ova, . . . .         | 0     | 0     | 0     | 0     | 2     | 0     | 1     | 3     | 0     | 0     | 0     | 0     |
| Rotifer, . . . .                | 0     | 1     | 0     | 0     | 0     | 0     | 3     | 0     | 0     | 0     | 0     | 0     |
| Crustacea, Daphnia, . . . .     | 0     | 0     | 0     | 0     | 0     | .30   | .02   | 0     | 0     | 0     | 0     | 0     |
| Miscellaneous.                  |       |       |       |       |       |       |       |       |       |       |       |       |
| Acarina, . . . .                | 0     | 0     | 0     | 0     | 0     | 0     | 0     | .08   | 0     | 0     | 0     | 0     |
| Zoöglæa, . . . .                | 0     | 0     | 0     | 0     | 0     | 0     | 3     | 0     | 0     | 0     | 0     | 0     |
| TOTAL, . . . .                  | 26    | 39    | 10    | 4     | 2,218 | 645   | 430   | 533   | 108   | 147   | 23    | 13    |

## ORANGE.

*Chemical Examination of Water from the Distributing Reservoir of the Orange Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                     |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 13685   | 1895.<br>Jan. 16    | V. slight.          | V. slight.        | .40    | 3.10                            | 1.20                 | .0034    | .0114       | .0102      | .0012           | .15       | .0070          | .0000     | .3673            | 0.9       |
| 13868   | Feb. 20             | None.               | V. slight.        | .23    | 2.85                            | 0.90                 | .0006    | .0082       | .0052      | .0030           | .08       | .0050          | .0000     | .2925            | 0.9       |
| 14018   | Mar. 20             | V. slight.          | Slight.           | .23    | 3.15                            | 1.05                 | .0000    | .0146       | .0136      | .0010           | .15       | .0100          | .0001     | .3492            | 0.8       |
| 14178   | Apr. 17             | V. slight.          | Cons.,<br>earthy. | .20    | 2.55                            | 0.95                 | .0014    | .0106       | .0086      | .0020           | .13       | .0070          | .0000     | .3160            | 0.6       |
| 14330   | May 20              | Distinct.           | Slight.           | .20    | 2.70                            | 1.20                 | .0000    | .0120       | .0080      | .0040           | .13       | .0000          | .0000     | .3492            | 0.9       |
| 14505   | June 19             | Slight.             | Slight.           | .25    | 3.10                            | 1.40                 | .0014    | .0130       | .0120      | .0010           | .13       | .0030          | .0000     | .3705            | 0.6       |
| 14695   | July 23             | V. slight.          | Slight.           | .20    | 3.10                            | 1.05                 | .0000    | .0118       | .0096      | .0022           | .18       | .0030          | .0000     | .2850            | 0.8       |
| 14897   | Aug. 21             | Distinct,<br>white. | Slight,<br>white. | .25    | 3.50                            | 1.50                 | .0000    | .0122       | .0106      | .0016           | .12       | .0030          | .0000     | .4446            | 0.5       |
| 15224   | Sept. 20            | Slight.             | Slight.           | .25    | 3.60                            | 1.05                 | .0006    | .0132       | .0122      | .0010           | .16       | .0070          | .0000     | .3198            | 0.8       |
| 15428   | Oct. 24             | Slight,<br>green.   | Slight,<br>green. | .15    | 3.20                            | 0.70                 | .0000    | .0098       | .0056      | .0042           | .17       | .0000          | .0000     | .2870            | 0.8       |
| 15593   | Nov. 21             | None.               | Slight.           | .08    | 3.25                            | 0.70                 | .0000    | .0010       | .0010      | .0000           | .15       | .0030          | .0000     | .1264            | 0.8       |
| 15775   | Dec. 18             | None.               | V. slight.        | .25    | 3.00                            | 1.05                 | .0002    | .0066       | .0058      | .0008           | .11       | .0090          | .0000     | .3811            | 0.5       |
| Av.     | 1895                | .....               | .....             | .22    | 3.09                            | 1.06                 | .0006    | .0103       | .0085      | .0018           | .14       | .0047          | .0000     | .3240            | 0.7       |
| Av.     | 1894                | .....               | .....             | .52    | 3.68                            | 1.58                 | .0007    | .0171       | .0146      | .0025           | .14       | .0028          | .0001     | .6136            | 0.8       |

NOTE to analyses of 1895: Odor, in January and March, none; in October, faintly oily; at other times vegetable, and rarely unpleasant. The odor of the October sample was stronger on heating. The odor of the sample collected in May was decidedly oily on heating. — The samples were collected from the reservoir.

*Microscopical Examination of Water from the Distributing Reservoir of the Orange Water Works.*

[Number of organisms per cubic centimeter.]

|                               | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|-------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                               | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . . . | 17    | 23    | 21    | 18    | 21    | 21    | 25    | 23    | 21    | 25    | 23    | 20    |
| Number of sample, . . . . .   | 13685 | 13868 | 14018 | 14178 | 14330 | 14505 | 14695 | 14897 | 15224 | 15428 | 15593 | 15775 |
| PLANTS.                       |       |       |       |       |       |       |       |       |       |       |       |       |
| Algae, . . . . .              | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 211   | 1     | 0     | 0     | 0     |
| Chlorococcus, . . . . .       | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 49    | 0     | 0     | 0     | 0     |
| Raphidium, . . . . .          | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 140   | 1     | 0     | 0     | 0     |
| Staurostrum, . . . . .        | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 22    | 0     | 0     | 0     | 0     |
| Fungi, Crenothrix, . . . . .  | pr.   | 0     | 0     | 0     | 0     | 0     | 0     | 12    | 1     | 0     | 6     | 0     |

## ORANGE.

*Microscopical Examination of Water from the Distributing Reservoir of the Orange Water Works.*

[Number of organisms per cubic centimeter.]

|                               | 1895. |      |      |      |      |       |       |      |       |      |      |      |
|-------------------------------|-------|------|------|------|------|-------|-------|------|-------|------|------|------|
|                               | Jan.  | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
| <b>ANIMALS.</b>               |       |      |      |      |      |       |       |      |       |      |      |      |
| Rhizopoda, Actinophrys, . . . | 0     | 0    | 0    | 0    | 50   | 0     | 0     | 44   | 0     | 0    | 0    | 0    |
| Infusoria, . . . . .          | 0     | 72   | 174  | 84   | 58   | 0     | 5     | 38   | 19    | 124  | 1    | 0    |
| Dinobryon, . . . . .          | 0     | 0    | 9    | 84   | 0    | 0     | 0     | 11   | 17    | 0    | 0    | 0    |
| Dinobryon cases, . . . . .    | 0     | 72   | 164  | 0    | 0    | 0     | 2     | 0    | 1     | 100  | 0    | 0    |
| Mallomonas, . . . . .         | 0     | 0    | 0    | 0    | 0    | 0     | 3     | 0    | 0     | 0    | 0    | 0    |
| Peridinium, . . . . .         | 0     | 0    | 1    | 0    | 0    | 0     | 0     | 27   | 1     | 0    | 1    | 0    |
| Uroglena, . . . . .           | 0     | 0    | 0    | 0    | 58   | 0     | 0     | 0    | 0     | 24   | 0    | 0    |
| Vermes, . . . . .             | 0     | 0    | 0    | 0    | 0    | 0     | 3     | pr.  | 3     | 0    | 0    | 0    |
| Anura, . . . . .              | 0     | 0    | 0    | 0    | 0    | 0     | 3     | pr.  | 1     | 0    | 0    | 0    |
| Rotatorian ova, . . . . .     | 0     | 0    | 0    | 0    | 0    | 0     | 0     | 0    | 2     | 0    | 0    | 0    |
| Miscellaneous, . . . . .      | 0     | 0    | 0    | 0    | 0    | 0     | .02   | 156  | .06   | 0    | 0    | 0    |
| Acarina, . . . . .            | 0     | 0    | 0    | 0    | 0    | 0     | .02   | 0    | .06   | 0    | 0    | 0    |
| Zoöglæa, . . . . .            | 0     | 0    | 0    | 0    | 0    | 0     | 0     | 156  | 0     | 0    | 0    | 0    |
| TOTAL, . . . . .              | pr.   | 72   | 174  | 84   | 108  | 0     | 12    | 461  | 24    | 124  | 7    | 0    |

**WATER SUPPLY OF PALMER FIRE DISTRICT, PALMER. — PALMER WATER COMPANY.***Chemical Examination of Water from Faucets in Palmer supplied from the Works of the Palmer Water Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |       | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-------|------------------|-----------|
|         |                     | Turbidity.        | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            | Dissolved. |           | Suspended.  |       |                  |           |
|         |                     |                   |                |        |                         |                   |          | Total.      | Dissolved. |            |           |             |       |                  |           |
| 1895.   |                     |                   |                |        |                         |                   |          |             |            |            |           |             |       |                  |           |
| 14617   | July 15             | Distinct.         | Slight.        | .45    | 3.65                    | 1.30              | .0004    | .0130       | .0096      | .0034      | .14       | .0050       | .0000 | .3432            | 1.1       |
| 14858   | Aug. 19             | Distinct, clayey. | Slight, brown. | .90    | 4.85                    | 2.50              | .0004    | .0238       | .0220      | .0018      | .15       | .0050       | .0000 | .8112            | 1.8       |

Odor of the first sample, distinctly vegetable and unpleasant, becoming also oily on heating; of the last, distinctly vegetable and disagreeable.

*Microscopical Examination.*

No. 14617. Diatomaceæ, Cocconeis, 1; Cymbella, 3; Fragilaria, 7; Melostra, 8; Navicula, 4; Pinnularia, 4; Syndra, 10; Tabellaria, 3. Cyanophyceæ, Anabæna, 5. Algæ, Gloeocapsa, 1; Pediastrum, 1. Fungi, Crenothrix, 21. Infusoria, Dinobryon, 1,480; Peridinium, 1. Crustacea, Daphnia, .02. Total, 1,549.

No. 14858. Diatomaceæ, Cyclotella, 3; Cymbella, 1; Diatoma, 5; Fragilaria, 8; Melostra, 14; Meridion, 4; Navicula, 8; Pinnularia, 1; Stephanodiscus, 1; Syndra, 8; Tabellaria, 7. Cyanophyceæ, Chroococcus, 2. Algæ, Pediastrum, 2; Protococcus, 1; Rhaphidium, 2. Fungi, Crenothrix, 4; Molds, 1. Infusoria, Peridinium, 4. Miscellaneous, Zoöglæa, 200. Total, 276.

PAXTON

PAXTON.

The advice of the State Board of Health to the town of Paxton relative to the use of water from Asnebumskit Pond as a public water supply may be found on page 38 of this volume. An analysis of a sample of water collected from this source in August, 1893, may be found on page 394 of the annual report for 1894.

WATER SUPPLY OF PEABODY.

*Chemical Examination of Water from Brown's Pond, Peabody.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.               |             |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| Apr. 8              | Distinct.   | Slight.    | .12    | 3.45                            | 1.15                 | .0036    | .0168       | .0124      | .0044           | .58       | .0070          | .0000     | .2425            | 0.8       |
| July 8              | Slight.     | Cons.      | .25    | 3.05                            | 1.15                 | .0002    | .0172       | .0154      | .0018           | .57       | .0050          | .0000     | .3476            | 0.5       |
| Oct. 8              | None.       | V. slight. | .12    | 2.75                            | 1.10                 | .0000    | .0162       | .0146      | .0016           | .59       | .0000          | .0000     | .2886            | 0.6       |
| .....               | .....       | .....      | .16    | 3.08                            | 1.13                 | .0013    | .0167       | .0141      | .0026           | .58       | .0040          | .0000     | .2929            | 0.6       |

for of the first sample, faintly vegetable, becoming disagreeable on heating; of the second, distinctly ble and mouldy; of the third, very faintly vegetable. — The samples were collected from the

*Microscopical Examination of Water from Brown's Pond, Peabody.*

[Number of organisms per cubic centimeter.]

|                      | 1893.  |       |          |
|----------------------|--------|-------|----------|
|                      | April. | July. | October. |
| amination, . . . . . | 9      | 9     | 10       |
| f sample, . . . . .  | 14105  | 14583 | 15329    |
| PLANTS.              |        |       |          |
| oese, . . . . .      | 8      | 42    | 1        |
| ella, . . . . .      | 0      | 4     | 0        |
| la, . . . . .        | 0      | 5     | 0        |
| , . . . . .          | 0      | 1     | 1        |
| , . . . . .          | 3      | 32    | 0        |
| a, . . . . .         | 5      | 0     | 0        |
| oese, . . . . .      | 0      | 21    | 0        |
| , . . . . .          | 0      | 17    | 0        |
| dia, . . . . .       | 0      | 4     | 0        |

**PEABODY.***Microscopical Examination of Water from Brown's Pond, Peabody — Concluded.*

[Number of organisms per cubic centimeter.]

|                              |  | 1895.      |           |          |
|------------------------------|--|------------|-----------|----------|
|                              |  | April.     | July.     | October. |
| <b>PLANTS — Con.</b>         |  |            |           |          |
| Algae, . . . . .             |  | 21         | 14        | 0        |
| Glæocapsa, . . . . .         |  | 0          | 2         | 0        |
| Protococcus, . . . . .       |  | 21         | 9         | 0        |
| Scenedesmus, . . . . .       |  | 0          | 3         | 0        |
| Fungi, Crenothrix, . . . . . |  | 0          | 5         | 1        |
| <b>ANIMALS.</b>              |  |            |           |          |
| Infusoria, . . . . .         |  | 584        | 2         | 0        |
| Dinobryon, . . . . .         |  | 248        | 0         | 0        |
| Dinobryon cases, . . . . .   |  | 332        | 0         | 0        |
| Mallomonas, . . . . .        |  | 3          | 0         | 0        |
| Peridinium, . . . . .        |  | 0          | 2         | 0        |
| Trachelomonas, . . . . .     |  | 1          | 0         | 0        |
| <b>TOTAL, . . . . .</b>      |  | <b>613</b> | <b>84</b> | <b>1</b> |

*Chemical Examination of Water from Spring Pond, Peabody.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |                 |           | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------|--------|-------------------------|-------------------|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |                 | Chlorine. | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                   |        |                         |                   |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |           |
| 14104   | 1895.<br>Apr. 8     | Distinct.   | Cons.,<br>earthy. | .02    | 4.45                    | 1.25              | .0016    | .0132       | .0092      | .0040           | .78       | .0040       | .0000     | .1617            | 1.7       |
| 14582   | July 8              | Slight.     | Cons.             | .05    | 3.90                    | 0.80              | .0014    | .0164       | .0136      | .0028           | .69       | .0000       | .0000     | .1896            | 1.5       |
| 15330   | Oct. 8              | V. slight.  | Slight,<br>brown. | .03    | 3.75                    | 1.55              | .0000    | .0122       | .0098      | .0024           | .71       | .0000       | .0000     | .1778            | 1.6       |
| Av.     | .....               | .....       | .....             | .03    | 4.03                    | 1.20              | .0010    | .0139       | .0109      | .0030           | .73       | .0013       | .0000     | .1764            | 1.7       |

Odor of the first sample, distinctly disagreeable; of the second, decidedly vegetable and mouldy; of the last, very faintly vegetable. — The samples were collected from the pond.

PEABODY.

Microscopical Examination of Water from Spring Pond, Peabody.

[Number of organisms per cubic centimeter.]

|                               | 1895.  |       |          |
|-------------------------------|--------|-------|----------|
|                               | April. | July. | October. |
| Day of examination, . . . . . | 9      | 9     | 10       |
| Number of sample, . . . . .   | 14104  | 14582 | 15330    |
| PLANTS.                       |        |       |          |
| Diatomaceæ, . . . . .         | 1      | 78    | 244      |
| Pinnularia, . . . . .         | 0      | 2     | 0        |
| Synedra, . . . . .            | 1      | 4     | 52       |
| Tabellaria, . . . . .         | 0      | 72    | 192      |
| Cyanophyceæ, . . . . .        | 0      | 16    | 34       |
| Anabæna, . . . . .            | 0      | 16    | 0        |
| Chroococcus, . . . . .        | 0      | 0     | 2        |
| Microcystis, . . . . .        | 0      | 0     | 82       |
| Algæ, . . . . .               | 0      | 3     | 9        |
| Protococcus, . . . . .        | 0      | 3     | 0        |
| Raphidium, . . . . .          | 0      | 0     | 9        |
| Fungi, Crenothrix, . . . . .  | 0      | 6     | 0        |
| ANIMALS.                      |        |       |          |
| Infusoria, . . . . .          | 18     | 0     | 1        |
| Dinobryon cases, . . . . .    | 10     | 0     | 0        |
| Monas, . . . . .              | 7      | 0     | 0        |
| Peridinium, . . . . .         | 0      | 0     | 1        |
| Trachelomonas, . . . . .      | 1      | 0     | 0        |
| TOTAL, . . . . .              | 19     | 103   | 288      |

Chemical Examination of Water from the Lower Basin, Peabody Water Works

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE OF<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 14106   | 1895.<br>Apr. 8     | Distinct.   | Cons.,<br>earthy. | .02    | 5.00                            | 1.15                 | .0060    | .0096       | .0064      | .0032           | .66       | .0600          | .0003     | .1039            | 1.8       |
| 15331   | Oct. 8              | V. slight.  | Slight.           | .03    | 4.70                            | 1.75                 | .0022    | .0136       | .0124      | .0012           | .78       | .0180          | .0001     | .1466            | 2.1       |

Odor, none, becoming very faintly vegetable on heating. — The samples were collected from the basin.

Microscopical Examination.

No. 14106. Diatomaceæ, *Diatoma*, 1; *Synedra*, 4. Infusoria, *Ciliated infusorian*, 1; *Dinobryon*, 11; *Dinobryon cases*, 27. Total, 44.  
No. 15331. Diatomaceæ, *Cymbella*, 4; *Diatoma*, 4; *Navicula*, 2; *Synedra*, 2. Cyanophyceæ, *Anabæna*, 1. Algæ, *Pediastrum*, 1; *Raphidium*, 6. Total, 20.



**PEABODY.***Chemical Examination of Water from a Fountain in Peabody, supplied from the Peabody Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 14584   | 1895.<br>July 8     | Slight.     | Slight.   | .05    | 4.60                    | 1.15              | .0010    | .0154       | .0138      | .0016      | .75       | .0230       | .0004     | .1659            | 1.8       |

Odor, faintly vegetable, becoming stronger and unpleasant on heating.

*Microscopical Examination.*

Diatomaceæ, *Cyclotella*, 2; *Cymbella*, 1; *Navicula*, 5; *Pinnularia*, 4; *Synedra*, 7. Algae, *Cosmarium*, 1; *Pediastrum*, 1; *Protococcus*, 41; *Raphidium*, 1; *Scenedemus*, 3. Fungi, *Crenothrix*, 4. Infusoria, *Peridinium*, 10. Vermes, *Anurea*, 3. Total, 83.

**PEPPERELL.**

The advice of the State Board of Health to the town of Pepperell in relation to a water supply for the town may be found on pages 38-40 of this volume. In connection with the investigation, samples of water were taken from five different sources in the town and in its vicinity, the results of the analyses of which are given below.

*Chemical Examination of Water from Brooks in Pepperell and Vicinity.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |           |
| 1895.   |                     |             |           |        |                         |                   |          |             |            |                 |           |             |           |                  |           |
| 14273   | May 10              | V. slight.  | Slight.   | 0.40   | 3.90                    | 1.90              | .0006    | .0190       | .0174      | .0016           | .19       | .0000       | .0000     | .6891            | 1.1       |
| 14274   | May 10              | V. slight.  | Cons.     | 1.05   | 5.30                    | 2.85              | .0010    | .0252       | .0238      | .0014           | .19       | .0030       | .0000     | .8739            | 2.2       |
| 14275   | May 10              | V. slight.  | Cons.     | 0.70   | 5.25                    | 2.05              | .0014    | .0128       | .0120      | .0008           | .22       | .0050       | .0000     | .5390            | 3.0       |
| 14276   | May 10              | V. slight.  | Cons.     | 0.78   | 3.20                    | 2.10              | .0018    | .0186       | .0168      | .0018           | .16       | .0000       | .0000     | .7548            | 0.9       |
| 15405   | Oct. 22             | V. slight.  | Slight.   | 0.90   | 5.80                    | 2.75              | .0010    | .0332       | .0310      | .0022           | .30       | .0020       | .0001     | .9360            | 2.5       |

Odor of the first four samples, distinctly vegetable; of the last, none, becoming distinctly vegetable on heating. — The samples were collected as follows: No. 14273, from Gulf Brook at the road crossing just above its junction with the Nisittisett River; No. 14274, from Unquetenasset Brook, below the Worcester and Nashua Division of the Boston & Maine Railroad, just above the crossing of the road from Pepperell to Hollis, New Hampshire; No. 14275, from Sucker Brook, just above where it joins the Nisittisett River; No. 14276, from the Nisittisett River, just above Sucker Brook; No. 15405, from Kemp's millpond, on Robinson's Brook, South Pepperell.

*Microscopical Examination.*

The number of organisms per cubic centimeter found in these samples was as follows: No. 14273, 54; No. 14274, 174; No. 14275, 54; No. 14276, 297; No. 15405, 70.

## PITTSFIELD.

## WATER SUPPLY OF PITTSFIELD.

In the latter part of 1895 the city of Pittsfield constructed works for taking water for the supply of the city from Mill Brook in Washington and Lenox. A dam was constructed upon the brook, forming a small reservoir at such an elevation that the water will be supplied to the city by gravity. It is said that no water was supplied to the city from this source during 1895.

In the latter part of the year the city applied to the State Board of Health for advice with reference to increasing its water supply, and during the investigations relative to an additional water supply samples of water from several sources in the vicinity of the city were analyzed, the results of which are given in the tables which follow. Analyses of samples of water from West Pond and Roaring Brook may be found under Washington.

The advice of the State Board of Health to the Onota Water Company of Pittsfield relative to the introduction of water from May Brook for the supply of that portion of the city of Pittsfield in the vicinity of West Street may be found on pages 40 and 41 of this volume.

*Chemical Examination of Water from Sacket Brook in the Vicinity of the Pumping Station of the Pittsfield Water Works.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.<br>Aug. 13    | None.       | Slight.   | .05    | 11.50                           | 1.95                 | .0004    | .0042       | .0034      | .0005           | .07       | .0100          | .0001     | .0936            | 9.5       |

or, none, becoming distinctly vegetable on heating. — The sample was collected from the brook.

*Microscopical Examination.*

Diaceae, *Cyclotella*, 1; *Cymbella*, 11; *Fragilaria*, 3; *Melosira*, 11; *Navicula*, 5; *Synedra*, 31.  
yeae, *Oscillatoria*, 2. Algae, *Scenedesmus*, 2. Fungi, *Crenothrix*, 2. Total, 68.

**PITTSFIELD.***Chemical Examination of Water from Sachem and Hollow Brooks, Lanesborough.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
|         | <b>1895.</b>        |             |                |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 14819   | Aug. 12             | None.       | V. slight.     | .08    | 8.80                    | 0.70              | .0000    | .0034       | .0016      | .0018      | .07       | .0170       | .0001     | .1245            | 6.9       |
| 15629   | Nov. 27             | Slight.     | Cons., brown.  | .15    | 7.73                    | 1.40              | .0004    | .0080       | .0060      | .0020      | .07       | .0400       | .0000     | .2324            | 5.8       |
| 14823   | Aug. 12             | None.       | Slight.        | .03    | 6.80                    | 0.50              | .0000    | .0016       | .0012      | .0004      | .09       | .0100       | .0000     | .0468            | 5.3       |
| 15625   | Nov. 27             | Slight.     | Cons., earthy. | .08    | 3.40                    | 0.75              | .0002    | .0050       | .0042      | .0005      | .10       | .0080       | .0000     | .1326            | 2.1       |

Odor of the first sample, none; of the second, faintly vegetable, becoming stronger on heating; of the third, none, becoming distinctly aromatic on heating; of the last sample, faintly vegetable. — The first two samples were collected from Sachem Brook, a short distance above its junction with Hollow Brook; the last two samples from Hollow Brook, a short distance above its junction with Sachem Brook.

*Microscopical Examination.*

An insignificant number of organisms was found in each of these samples.

*Chemical Examination of Water from Smith and Lulu Brooks, Pittsfield.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 14820   | 1895.<br>Aug. 12    | None.       | V. slight. | .05    | 3.75                            | 0.40                 | .0000    | .0024       | .0016      | .0008           | .08       | .0030          | .0001     | .0858            | 2.7       |
| 15631   | Nov. 27             | None.       | Slight.    | .08    | 2.05                            | 0.60                 | .0000    | .0050       | .0038      | .0012           | .11       | .0000          | .0000     | .1388            | 6.6       |
| 15633   | Nov. 27             | -           | -          | .33    | -                               | -                    | -        | -           | -          | -               | .11       | -              | -         | -                | 2.1       |

Odor, none. — The first two samples were collected from Smith Brook at the second road crossing above West Street, and the last sample from Lulu Brook, at the first road crossing above Onota Lake.

*Microscopical Examination.*

No. 15633 was not examined. An insignificant number of organisms was found in each of the other samples.

## PITTSFIELD.

*Chemical Examination of Water from Pontoosuc Lake, Pittsfield.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 14886   | 1895.<br>Aug. 20    | Slight.     | Slight.   | .04    | 8.35                    | 1.65              | .0014    | .0144       | .0106      | .0038      | .10       | .0000       | .0000     | .1482            | 6.0       |
| 14887   | Aug. 20             | Slight.     | Slight.   | .04    | 8.40                    | 1.30              | .0014    | .0126       | .0110      | .0016      | .11       | .0000       | .0000     | .1560            | 6.0       |

Odor, distinctly vegetable and mouldy. — The first sample was collected near the dam; the last, near the Point of Pines.

*Microscopical Examination.*

An insignificant number of organisms was found in each of these samples.

*Chemical Examination of Water from May Brook, Pittsfield.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA.    |        |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|----------------|--------|-------------------------|-------------------|-------------|--------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.      | Color. | Total.                  | Loss on Ignition. | Albuminoid. |        |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                |        |                         |                   | Free.       | Total. | Dissolved. | Suspended. |           |             |           |                  |           |
| 14139   | 1895.<br>Apr. 12    | V. slight.  | Cons., earthy. | .03    | 1.95                    | 0.45              | .0000       | .0030  | .0016      | .0014      | .08       | .0200       | .0000     | .0948            | 1.1       |
| 14189   | Apr. 16             | -           | -              | .08    | -                       | -                 | -           | -      | -          | -          | .11       | -           | -         | -                | 1.4       |
| 14821   | Aug. 12             | None.       | V. slight.     | .02    | 5.85                    | 0.75              | .0008       | .0010  | .0004      | .0006      | .05       | .0100       | .0000     | .0468            | 4.3       |
| 15630   | Nov. 27             | None.       | Slight.        | .07    | 2.45                    | 0.90              | .0000       | .0054  | .0044      | .0010      | .13       | .0070       | .0000     | .1560            | 0.9       |

Odor, none. — The samples were collected at the site of a proposed reservoir, about half a mile above West Street.

*Microscopical Examination*

An insignificant number of organisms was found in these samples.

|                           | 1895. |       |       |       |       |       |       |       |       |       |       |             |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------------|
|                           | Jan.  | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov. Dec.   |
| Day of examination, . . . | 9     | 24    | 13    | 13    | 10    | 13    | 12    | 17    | 15    | 11    | 10    | 14 10       |
| Number of sample, . . .   | 13826 | 13704 | 13798 | 13958 | 14123 | 14277 | 14448 | 14628 | 14838 | 15127 | 15332 | 15538 15701 |
| PLANTS.                   |       |       |       |       |       |       |       |       |       |       |       |             |
| Diatomaceæ, . . .         | 18    | 22    | 0     | 10    | 23    | 23    | 5     | 17    | 5     | 6     | 3     | 4 13        |
| Asterionella, . . .       | 0     | 0     | 0     | 9     | 8     | 7     | 0     | 8     | 0     | 0     | 1     | 0 10        |
| Cyclotella, . . .         | 1     | 0     | 0     | 0     | 4     | 1     | 0     | 0     | 2     | 2     | 0     | 0 0         |
| Synedra, . . .            | 17    | 22    | 0     | 1     | 11    | 14    | 5     | 7     | pr.   | 2     | 1     | 0 3         |
| Tabellaria, . . .         | 0     | 0     | 0     | pr.   | 0     | 1     | 0     | 2     | 3     | 2     | 1     | 4 0         |
| Cyanophyceæ, . . .        | 0     | 0     | 0     | 0     | 0     | 0     | 7     | 3     | 16    | 22    | 22    | 7 0         |
| Anabaena, . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 7     | 0     | 13    | 2     | 1     | 0 0         |
| Microcystis, . . .        | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 3     | 3     | 8     | 18    | 7 0         |
| Oscillaria, . . .         | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 12    | 3     | 0 0         |

## PLYMOUTH.

*Microscopical Examination of Water from Little South Pond, Plymouth—Concluded.*

[Number of organisms per cubic centimeter.]

|                             | 1895. |      |      |      |      |      |       |       |      |       |      |      |      |
|-----------------------------|-------|------|------|------|------|------|-------|-------|------|-------|------|------|------|
|                             | Jan.  | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
| PLANTS—Con.                 |       |      |      |      |      |      |       |       |      |       |      |      |      |
| Algae, . . . . .            | 0     | 2    | 0    | 0    | 0    | 0    | 0     | 40    | 154  | 21    | 0    | 0    | 0    |
| Protococcus, . . . .        | 0     | 2    | 0    | 0    | 0    | 0    | 0     | 40    | 154  | 13    | 0    | 0    | 0    |
| Staurogenia, . . . .        | 0     | 0    | 0    | 0    | 0    | 0    | 0     | 0     | 0    | 8     | 0    | 0    | 0    |
| ANIMALS.                    |       |      |      |      |      |      |       |       |      |       |      |      |      |
| Infusoria, . . . . .        | 157   | 104  | 82   | 87   | 1    | 5    | 0     | 434   | 1    | 1     | 3    | 3    | 251  |
| Dinobryon, . . . . .        | 30    | 13   | 11   | 68   | 0    | 0    | 0     | 424   | 0    | 0     | 0    | 0    | 0    |
| Dinobryon cases, . . .      | 93    | 90   | 60   | 17   | 1    | 5    | 0     | 0     | 0    | 0     | 0    | 0    | 1    |
| Mallomonas, . . . . .       | 0     | 0    | 0    | 0    | 0    | 0    | 0     | 6     | 1    | 0     | 3    | 0    | 0    |
| Opalina, . . . . .          | 0     | 0    | 0    | 0    | 0    | 0    | 0     | 4     | 0    | 0     | 0    | 0    | 0    |
| Peridinium, . . . . .       | 0     | 0    | 1    | 2    | 0    | 0    | 0     | 0     | 0    | 1     | 0    | 0    | 0    |
| Uroglena, . . . . .         | 34    | 1    | 10   | 0    | 0    | 0    | 0     | 0     | 0    | 0     | 0    | 3    | 250  |
| Miscellaneous, Zoöglæa, . . | 0     | 0    | 0    | 0    | 0    | 30   | 0     | 0     | 0    | 16    | 0    | 40   | 0    |
| TOTAL, . . . . .            | 175   | 128  | 82   | 97   | 24   | 58   | 12    | 494   | 176  | 66    | 28   | 54   | 264  |

**WATER SUPPLY OF PROVINCETOWN.***Chemical Examination of Water from the Tubular Wells of the Provincetown Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                |        | Residue on Evaporation. | AMMONIA. |           | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|----------------|--------|-------------------------|----------|-----------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.      | Color. |                         | Free.    | Albimoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 13774   | 1895. Feb. 6        | Decided.    | Cons., rusty.  | 0.80   | 7.90                    | .0062    | .0120     | 1.80      | .0030       | .0000     | .8137            | 2.3       | .2200 |
| 13949   | Mar. 6              | Decided.    | Slight, rusty. | 1.30   | 7.30                    | .0068    | .0192     | 2.23      | .0070       | .0000     | .6737            | 2.3       | .3150 |
| 4092    | Apr. 3              | Distinct.   | Cons., rusty.  | 1.20   | 8.50                    | .0080    | .0094     | 2.25      | .0070       | .0000     | .6968            | 2.1       | .3500 |
| 4436    | June 6              | Decided.    | Cons., rusty.  | 1.20   | 9.40                    | .0052    | .0102     | 2.35      | .0030       | .0000     | .7752            | 2.7       | .4200 |
| 4793    | Aug. 9              | Decided.    | Cons., rusty.  | 1.30   | 9.70                    | .0070    | .0112     | 2.18      | .0040       | .0000     | .8424            | 1.8       | .4300 |
| 5322    | Oct. 7              | Decided.    | Cons., rusty.  | 1.40   | 8.60                    | .0080    | .0110     | 2.35      | .0030       | .0000     | .8073            | 2.5       | .4200 |
| 1692    | Dec. 9              | Distinct.   | Cons., rusty.  | 1.30   | 8.50                    | .0108    | .0104     | 2.10      | .0030       | .0000     | .7995            | 1.7       | .4800 |
| Av.     | .....               | .....       | .....          | 1.21   | 8.56                    | .0074    | .0106     | 2.18      | .0043       | .0000     | .7727            | 2.2       | .3764 |

*Averages by Years.*

|   |      |   |   |      |      |       |       |      |       |       |       |     |       |
|---|------|---|---|------|------|-------|-------|------|-------|-------|-------|-----|-------|
| - | 1903 | - | - | 0.99 | 7.65 | .0027 | .0082 | 2.08 | .0023 | .0001 | .7425 | 1.4 | .1340 |
| - | 1904 | - | - | 1.09 | 7.91 | .0043 | .0090 | 2.19 | .0039 | .0000 | .6875 | 1.7 | .2212 |
| - | 1906 | - | - | 1.21 | 8.56 | .0074 | .0106 | 2.18 | .0043 | .0000 | .7727 | 2.2 | .3764 |

**NOTE** to analyses of 1905: Odor in February and June, faintly vegetable; at other times, none. On rising, vegetable odors were developed in all of the samples except that collected in August, which had earthy odor.—The samples were collected from a faucet at the pumping station.

## PROVINCETOWN.

*Microscopical Examination of Water from the Tubular Wells of the Provincetown Water Works.*

[Number of organisms per cubic centimeter.]

|                                      | 1895. |       |       |        |       |       |       |
|--------------------------------------|-------|-------|-------|--------|-------|-------|-------|
|                                      | Feb.  | Mar.  | Apr.  | June.  | Aug.  | Oct.  | Dec.  |
| Day of examination, . . . . .        | 7     | 8     | 4     | 7      | 10    | 8     | 10    |
| Number of sample, . . . . .          | 13774 | 13949 | 14092 | 14436  | 14793 | 15322 | 15692 |
| PLANTS.                              |       |       |       |        |       |       |       |
| Fungi, <i>Crenothrix</i> , . . . . . | 13    | 1,240 | 148   | 12,880 | 36    | 736   | 28    |

*Chemical Examination of Water from Faucets in Provincetown supplied from the Provincetown Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | 1895.               |                  |           |        |                         |          |             |           |             |           |                  |           |       |
| 13619   | Jan. 7              | Distinct, milky. | Slight.   | 1.00   | 6.90                    | .0014    | .0110       | 2.17      | .0040       | .0000     | .6435            | 1.6       | .1700 |
| 15693   | Dec. 9              | Decided.         | Cons.     | 1.20   | 9.00                    | .0014    | .0146       | 2.19      | .0000       | .0000     | .6786            | 2.6       | .3100 |

Odor of the first sample, very faintly unpleasant, becoming faintly vegetable on heating; of the second sample, none, becoming faintly vegetable on heating. — The samples represent water that had passed through the distributing tank.

*Microscopical Examination.*No. 13619. Fungi, *Crenothrix*, 4.No. 15693. Fungi, *Crenothrix*, 20,000.

QUINCY.

WATER SUPPLY OF QUINCY.

*Examination of Water from Town Brook just above the Storage Reservoir of the Quincy Water Works.*

[Parts per 100,000.]

| APPEARANCE. |            |            | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |     |
|-------------|------------|------------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|-----|
| Turbidity.  | Sediment.  | Color.     | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |     |
|             |            |            |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |     |
| 1           | V. slight. | V. slight. | 0.58                    | 3.95              | 1.45     | .0002       | .0094      | .0078      | .0016     | .64         | .0090     | .0000            | 0.4582    | 0.8 |
| 5           | V. slight. | Slight.    | 0.50                    | 4.40              | 0.90     | .0000       | .0134      | .0114      | .0020     | .66         | .0120     | .0000            | 0.4266    | 0.6 |
| 7           | V. slight. | Slight.    | 0.70                    | 3.05              | 1.35     | .0002       | .0204      | .0184      | .0020     | .49         | .0030     | .0000            | 0.6622    | 0.5 |
| 3           | V. slight. | Slight.    | 0.90                    | 3.75              | 2.25     | .0002       | .0258      | .0192      | .0066     | .59         | .0030     | .0000            | 0.8374    | 0.5 |
| 7           | V. slight. | Cons.      | 1.60                    | 5.50              | 2.95     | .0002       | .0280      | .0260      | .0020     | .57         | .0050     | .0000            | 1.2236    | 0.9 |
| 5           | V. slight. | Cons.      | 0.70                    | 4.25              | 1.85     | .0002       | .0154      | .0140      | .0014     | .56         | .0090     | .0002            | 0.4504    | 0.8 |
| 0           | V. slight. | Slight.    | 0.90                    | 4.45              | 1.30     | .0000       | .0164      | .0148      | .0016     | .58         | .0100     | .0001            | 0.5082    | 0.9 |
| 3           | None.      | V. slight. | 0.90                    | 4.85              | 1.55     | .0000       | .0172      | .0152      | .0020     | .76         | .0070     | .0002            | 0.3900    | 0.8 |
| 4           | None.      | Slight.    | 0.90                    | 4.80              | 1.60     | .0002       | .0212      | .0168      | .0044     | .60         | .0090     | .0000            | 0.5733    | 0.6 |
| 3           | Slight.    | Slight.    | 0.80                    | 4.95              | 1.90     | .0006       | .0170      | .0148      | .0022     | .64         | .0030     | .0001            | 0.7917    | 0.8 |
| 6           | None.      | V. slight. | 0.85                    | 4.10              | 2.10     | .0006       | .0132      | .0108      | .0024     | .56         | .0030     | .0000            | 0.7428    | 0.3 |
| 3           | Slight.    | Slight.    | 0.70                    | 3.70              | 1.75     | .0002       | .0150      | .0130      | .0020     | .44         | .0030     | .0000            | 0.6622    | 0.3 |
| -           | .....      | .....      | 0.84                    | 4.31              | 1.73     | .0002       | .0177      | .0152      | .0025     | .59         | .0061     | .0001            | 0.6439    | 0.6 |

*Averages by Years.*

|   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | - | 0.50 | 5.30 | 1.50 | .0000 | .0133 | -     | -     | .65 | .0080 | -     | -     | -   |
| - | - | 0.45 | 3.64 | 1.05 | .0001 | .0122 | -     | -     | .54 | .0070 | .0003 | -     | -   |
| - | - | 1.21 | 4.61 | 1.87 | .0013 | .0239 | .0208 | .0036 | .48 | .0073 | .0001 | -     | -   |
| - | - | 0.73 | 5.22 | 2.17 | .0024 | .0137 | .0155 | .0032 | .52 | .0125 | .0002 | -     | 1.3 |
| - | - | 0.72 | 4.22 | 1.50 | .0004 | .0166 | .0132 | .0024 | .49 | .0112 | .0001 | -     | 0.7 |
| - | - | 0.87 | 4.57 | 1.56 | .0041 | .0191 | .0159 | .0032 | .55 | .0114 | .0001 | -     | 0.8 |
| - | - | 0.93 | 4.58 | 1.81 | .0014 | .0168 | .0140 | .0028 | .57 | .0110 | .0001 | .7298 | 0.8 |
| - | - | 0.92 | 4.31 | 1.62 | .0003 | .0158 | .0134 | .0024 | .63 | .0030 | .0000 | .6379 | 0.6 |
| - | - | 0.84 | 4.31 | 1.73 | .0002 | .0177 | .0152 | .0025 | .59 | .0061 | .0001 | .6439 | 0.6 |

\* October.

† November and December.

analyses of 1896: Odor, vegetable; often also mouldy or unpleasant. — The samples were in the brook above the reservoir.

*Microscopical Examination.*

average number of organisms per cubic centimeter found in these samples was 75.



## QUINCY.

*Chemical Examination of Water from the Storage Reservoir of the Quincy Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|--------------------|-------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.         | Sediment.         | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                    |                   |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13696   | 1895.<br>Jan. 21    | V. slight.         | Slight.           | .50    | 3.90                    | 1.40              | .0008    | .0140       | .0110      | .0030      | .62       | .0050       | .0000     | .4542            | 0.8       |
| 13885   | Feb. 25             | Slight.            | Slight.           | .53    | 4.45                    | 1.40              | .0002    | .0196       | .0130      | .0066      | .68       | .0130       | .0000     | .4384            | 0.6       |
| 14048   | Mar. 27             | Distinct.          | Slight.           | .45    | 3.10                    | 0.60              | .0058    | .0188       | .0134      | .0054      | .66       | .0080       | .0001     | .3811            | 0.9       |
| 14207   | Apr. 23             | Distinct.          | Cons.             | .50    | 3.45                    | 1.65              | .0000    | .0234       | .0162      | .0092      | .61       | .0030       | .0002     | .5490            | 0.5       |
| 14381   | May 27              | Distinct.          | Cons.             | .75    | 4.70                    | 2.20              | .0000    | .0304       | .0194      | .0110      | .68       | .0000       | .0000     | .7030            | 0.3       |
| 14540   | June 25             | Distinct.          | Cons.,<br>green.  | .70    | 4.25                    | 2.10              | .0002    | .0348       | .0206      | .0142      | .70       | .0000       | .0000     | .6198            | 0.5       |
| 14735   | July 30             | Distinct.          | Cons.,<br>earthy. | .70    | 4.25                    | 1.75              | .0000    | .0382       | .0236      | .0146      | .66       | .0080       | .0000     | .6083            | 0.9       |
| 14931   | Aug. 28             | Decided.           | Cons.             | .65    | 4.60                    | 2.00              | .0008    | .0336       | .0208      | .0128      | .74       | .0030       | .0001     | .3510            | 0.8       |
| 15247   | Sept. 24            | Decided.           | Cons.,<br>green.  | .90    | 4.50                    | 1.80              | .0000    | .0466       | .0244      | .0222      | .68       | .0030       | .0000     | .4898            | 0.5       |
| 15436   | Oct. 28             | Decided,<br>green. | Cons.,<br>green.  | .90    | 4.95                    | 2.35              | .0004    | .0436       | .0244      | .0192      | .66       | .0000       | .0000     | .6903            | 0.5       |
| 15625   | Nov. 26             | Decided,<br>green. | Cons.,<br>green.  | .70    | 4.35                    | 2.25              | .0000    | .0340       | .0172      | .0168      | .58       | .0020       | .0000     | .7878            | 0.6       |
| 15790   | Dec. 23             | Distinct.          | Slight,<br>green. | .63    | 4.20                    | 1.70              | .0012    | .0224       | .0210      | .0014      | .52       | .0030       | .0000     | .5967            | 0.6       |
| Av.     | .....               | .....              | .....             | .66    | 4.22                    | 1.77              | .0008    | .0301       | .0187      | .0114      | .65       | .0040       | .0000     | .5558            | 0.7       |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1888* | - | - | .50 | 3.95 | 1.13 | .0030 | .0178 | .0182 | .0046 | .68 | .0150 | .0003 | -     | -   |
| - | 1889  | - | - | .92 | 3.76 | 1.19 | .0116 | .0303 | .0238 | .0065 | .53 | .0087 | .0003 | -     | -   |
| - | 1890  | - | - | .70 | 4.56 | 1.76 | .0085 | .0249 | .0178 | .0071 | .54 | .0166 | .0002 | -     | 1.3 |
| - | 1891  | - | - | .70 | 3.97 | 1.60 | .0027 | .0274 | .0178 | .0096 | .50 | .0100 | .0000 | -     | 0.7 |
| - | 1892  | - | - | .62 | 4.07 | 1.41 | .0051 | .0237 | .0175 | .0062 | .61 | .0098 | .0001 | -     | 0.9 |
| - | 1893  | - | - | .56 | 3.81 | 1.51 | .0052 | .0218 | .0172 | .0046 | .61 | .0104 | .0001 | .5052 | 0.3 |
| - | 1894  | - | - | .67 | 4.26 | 1.71 | .0020 | .0229 | .0167 | .0062 | .67 | .0053 | .0000 | .5969 | 0.8 |
| - | 1895  | - | - | .66 | 4.22 | 1.77 | .0008 | .0301 | .0187 | .0114 | .65 | .0040 | .0000 | .5558 | 0.7 |

\* November and December.

NOTE to analyses of 1895: Odor, distinctly vegetable; in January and February, also unpleasant, and from March to August, inclusive, disagreeable. — The samples were collected from the reservoir. For heights of water in this reservoir see table on page 286.

## QUINCY.

## Microscopical Examination of Water from the Storage Reservoir of the Quincy Water Works.

[Number of organisms per cubic centimeter.]

|                                 | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|---------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                 | Jan.  | Feb.  | Mar.  | Apr.  | May   | June  | Aug.  | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . .     | 23    | 27    | 29    | 26    | 29    | 26    | 1     | 30    | 26    | 30    | 29    | 24    |
| Number of sample, . . . .       | 13696 | 13885 | 14048 | 14207 | 14381 | 14540 | 14738 | 14931 | 15247 | 15436 | 15625 | 15790 |
| PLANTS.                         |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . .             | 0     | 0     | 1     | 30    | 421   | 794   | 28    | 129   | 44    | 7     | 63    | 2     |
| Asterionella, . . . .           | 0     | 0     | 0     | 2     | 7     | 0     | 6     | 128   | 16    | 0     | 5     | 0     |
| Diatoma, . . . .                | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 2     | 0     | 4     | 0     |
| Melosira, . . . .               | 0     | 0     | 0     | 8     | 6     | 0     | 4     | 0     | 0     | 5     | 0     | 0     |
| Synedra, . . . .                | 0     | 0     | 1     | 2     | 360   | 780   | 15    | 1     | 24    | 2     | 54    | 2     |
| Tabellaria, . . . .             | 0     | 0     | 0     | 18    | 46    | 14    | 2     | 0     | 2     | 0     | 0     | 0     |
| Algæ, . . . .                   | 0     | 0     | 44    | 0     | 56    | 0     | 62    | 402   | 0     | 1     | 18    | 0     |
| Conferva, . . . .               | 0     | 0     | 44    | 0     | 56    | 0     | 0     | 0     | 0     | 1     | 1     | 0     |
| Protococcus, . . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 10    | 396   | 0     | 0     | 5     | 0     |
| Raphidium, . . . .              | 0     | 0     | 0     | 0     | 0     | 0     | 52    | 6     | 0     | 0     | 12    | 0     |
| Fungi, Crenothrix, . . . .      | 0     | 0     | 0     | 1     | 0     | 0     | 4     | 0     | 36    | 48    | 0     | 0     |
| ANIMALS.                        |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . . .              | 48    | 1,110 | 112   | 169   | 73    | 256   | 288   | 182   | 152   | 0     | 2     | 0     |
| Dinobryon, . . . .              | 0     | 810   | 0     | 5     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, . . . .        | 0     | 68    | 44    | 108   | 4     | 0     | 3     | 0     | 0     | 0     | 0     | 0     |
| Monas, . . . .                  | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     |
| Tintinnidium, . . . .           | 0     | 0     | 0     | 0     | 3     | 0     | 1     | 0     | 0     | 0     | 0     | 0     |
| Peridinium, . . . .             | 48    | 232   | 68    | 56    | 64    | 256   | 284   | 180   | 152   | 0     | 2     | 0     |
| Vermes, . . . .                 | 0     | 0     | 0     | 0     | 1     | 0     | 4     | 1     | 2     | 0     | 1     | 0     |
| Anurea, . . . .                 | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 1     | 0     |
| Polyarthra, . . . .             | 0     | 0     | 1     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Rotatorian ova, . . . .         | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     |
| Rotifer, . . . .                | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 2     | 0     | 0     | 0     |
| Miscellaneous, Zoöglæa, . . . . | 0     | 0     | 268   | 0     | 0     | 0     | 0     | 0     | 80    | 80    | 0     | 3     |
| TOTAL, . . . .                  | 48    | 1,110 | 425   | 200   | 551   | 1,050 | 386   | 714   | 314   | 136   | 84    | 5     |

## Chemical Examination of Water from Blue Hill River, Braintree.

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 14736   | 1895.<br>July 30    | V. slight.  | Slight.   | .65    | 4.15                    | 1.95              | .0010    | .0250       | .0228      | .0022      | .54       | .0070       | .0000     | .6622            | 1.3       |

Odor, faintly vegetable. The sample was collected from the river at the point where it is crossed by West Street.

## Microscopical Examination.

The number of organisms per cubic centimeter found in this sample was 182.

**QUINCY.**

*Table showing Heights of Water in the Storage Reservoir of the Quincy Water Works on the Following Dates during 1895.*

[High-water mark is 86.71 feet above city base.]

| 1895.              |  | Heights<br>above City<br>Base. | 1895.              |  | Heights<br>above City<br>Base. |
|--------------------|--|--------------------------------|--------------------|--|--------------------------------|
|                    |  | Feet.                          |                    |  | Feet.                          |
| Jan. 1, . . . . .  |  | 85.71                          | July 1, . . . . .  |  | 84.68                          |
| Feb. 1, . . . . .  |  | 86.71                          | Aug. 1, . . . . .  |  | 83.16                          |
| March 1, . . . . . |  | 86.71                          | Sept. 1, . . . . . |  | 80.47                          |
| April 1, . . . . . |  | 86.71                          | Oct. 1, . . . . .  |  | 77.87                          |
| May 1, . . . . .   |  | 86.71                          | Nov. 1, . . . . .  |  | 80.39                          |
| June 4, . . . . .  |  | 86.44                          | Dec. 1, . . . . .  |  | 85.89                          |

**WATER SUPPLY OF RANDOLPH AND HOLBROOK.**

*Chemical Examination of Water from Great Pond in Randolph and Braintree.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended |           |                |           |                  |           |
| 14558   | 1895.<br>July 8     | Slight.     | Slight.   | .53    | 3.75                            | 1.90                 | .0004    | .0190       | .0172      | .0018          | .58       | .0050          | .0000     | .5767            | 1.4       |

Odor, very faintly vegetable, growing stronger on heating. — The sample was collected from a faucet in Holbrook.

*Microscopical Examination.*

Diatomaceæ, *Cyclotella*, 3; *Cymbella*, 1; *Fragilaria*, 2; *Melosira*, 2; *Pinnularia*, 1. Cyanophyceæ, *Anabæna*, 20; *Clathrocystis*, 1; *Microcystis*, 5. Algæ, *Glæocapsa*, 1; *Protococcus*, 41. Fungi, *Crenothrix*, 7. Total, 84.

**WATER SUPPLY OF READING.**

The advice of the State Board of Health relative to the purification of the public water supply of the town may be found on pages 41–45 of this volume. The results of analyses made during the investigation may be found on pages 297–300 of the annual report for 1894.

## READING.

*Chemical Examination of Water from the Filter-gallery of the Reading Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|----------------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment.      | Color. |                         | Free.    | Alb.-minhold. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1895.</b>        |                  |                |        |                         |          |               |           |             |           |                  |           |       |
| 13613   | Jan. 7              | Distinct, milky. | Cons., floe.   | 0.04   | 17.70                   | .0072    | .0122         | 1.00      | .0050       | .0000     | .3354            | 7.9       | .3300 |
| 13778   | Feb. 7              | Distinct.        | Slight, white. | 0.90   | 16.70                   | .0088    | .0126         | 1.02      | .0070       | .0000     | .4819            | 7.3       | .1900 |
| 12938   | Mar. 6              | Distinct, floe.  | Slight.        | 1.10   | 16.30                   | .0090    | .0150         | 0.94      | .0050       | .0000     | .5736            | 6.9       | .3000 |
| 14091   | Apr. 3              | Distinct.        | Cons., floe.   | 1.00   | 15.40                   | .0096    | .0116         | 0.78      | .0080       | .0001     | .3527            | 5.7       | .2100 |
| 14259   | May 7               | Distinct.        | Cons., floe.   | 1.20   | 14.00                   | .0082    | .0146         | 0.74      | .0030       | .0001     | .6583            | 5.3       | .1700 |
| 14433   | June 5              | Distinct.        | Slight, rusty. | 1.10   | 13.80                   | .0120    | .0162         | 0.72      | .0050       | .0000     | .6969            | 4.9       | .2000 |
| 14602   | July 10             | Distinct.        | Cons., floe.   | 0.50   | 10.80                   | .0082    | .0104         | 0.66      | .0050       | .0000     | .3871            | 3.8       | .0780 |
| 14780   | Aug. 7              | Distinct, milky. | Cons., yellow. | 0.35   | 9.60                    | .0060    | .0098         | 0.64      | .0080       | .0000     | .4290            | 3.9       | .1300 |
| 15000   | Sept. 4             | Decided.         | Cons., rusty.  | 0.40   | 10.80                   | .0074    | .0102         | 0.60      | .0000       | .0001     | .3822            | 3.5       | .1450 |
| 15346   | Oct. 9              | Decided, milky.  | Cons., floe.   | 0.40   | 8.30                    | .0068    | .0070         | 0.61      | .0000       | .0000     | .3432            | 2.7       | .1350 |
| 15499   | Nov. 7              | Distinct, milky. | Cons., rusty.  | 0.10   | 18.90                   | .0110    | .0086         | 0.48      | .0050       | .0000     | .3198            | 8.3       | .4400 |
| 15678   | Dec. 4              | Decided, milky.  | Cons., white.  | 0.20   | 14.30                   | .0110    | .0086         | 0.45      | .0070       | .0000     | .3750            | 6.4       | .4050 |
| Av.     | .....               | .....            | .....          | 0.61   | 13.88                   | .0088    | .0114         | 0.72      | .0048       | .0000     | .4446            | 5.5       | .2277 |

*Averages by Years.*

|   |             |   |   |      |       |       |       |     |       |       |       |     |       |
|---|-------------|---|---|------|-------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | <b>1891</b> | - | - | 0.13 | 12.96 | .0016 | .0063 | .43 | .0094 | .0001 | -     | 5.1 | -     |
| - | <b>1892</b> | - | - | 0.44 | 9.25  | .0042 | .0073 | .54 | .0071 | .0001 | -     | 3.4 | -     |
| - | <b>1893</b> | - | - | 0.64 | 10.08 | .0034 | .0087 | .56 | .0032 | .0001 | .3497 | 3.9 | .1251 |
| - | <b>1894</b> | - | - | 0.45 | 12.76 | .0043 | .0107 | .68 | .0029 | .0000 | .3509 | 5.0 | .2642 |
| - | <b>1895</b> | - | - | 0.61 | 13.88 | .0088 | .0114 | .72 | .0048 | .0000 | .4446 | 5.5 | .2277 |

NOTE to analyses of 1895: Odor, vegetable or none. On heating, the odor became unpleasant in several of the samples. — The samples were collected from a faucet at the pumping station.

*Microscopical Examination of Water from the Filter-gallery of the Reading Water Works.*

[Number of organisms per cubic centimeter.]

|                       | 1895. |       |       |       |       |       |       |        |        |        |       |       |
|-----------------------|-------|-------|-------|-------|-------|-------|-------|--------|--------|--------|-------|-------|
|                       | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.   | Sept.  | Oct.   | Nov.  | Dec.  |
| Day of examination, . | 8     | 9     | 8     | 4     | 8     | 7     | 11    | 8      | 7      | 11     | 11    | 5     |
| Number of sample, .   | 13613 | 13778 | 13938 | 14091 | 14259 | 14433 | 14602 | 14780  | 15000  | 15346  | 15499 | 15678 |
| <b>PLANTS.</b>        |       |       |       |       |       |       |       |        |        |        |       |       |
| Fungi, Crenothrix, .  | 64    | 1,000 | 2,400 | 1,180 | 1,040 | 6,300 | 4,000 | 13,600 | 10,000 | 12,000 | 1,384 | 2,360 |

## REVERE AND WINTHROP.

## WATER SUPPLY OF REVERE AND WINTHROP. — REVERE WATER COMPANY.

The works of the Revere Water Company for obtaining a supply of ground water at Cliftondale, Saugus, were enlarged in 1895 by sinking fifteen additional 2½-inch tubular wells in the immediate vicinity of those driven in previous years, forming an extension of the original system. The total number now connected with these works is 67.

The rapid increase in the amount of chlorine, residue on evaporation and hardness in the water of the wells located at Revere, which has been mentioned in previous reports, still continues, as may be seen in the table of yearly averages of analyses given below. It will be noticed in the table of monthly analyses in 1895 that the water deteriorated rapidly during the months when there was the greatest draft upon the wells, owing to the infiltration of sea water.

*Chemical Examination of Water from the Wells of the Revere Water Company at Revere.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |                 |        | Residue on Evaporation | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------------|-----------------|--------|------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.        | Sediment.       | Color. |                        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | 1895.               |                   |                 |        |                        |          |             |           |             |           |                  |           |       |
| 13635   | Jan. 8              | Slight, milky.    | Cons., rusty.   | .05    | 59.20                  | .0002    | .0018       | 18.36     | .0700       | .0003     | .0312            | 27.0      | .0470 |
| 13944   | Mar. 6              | None.             | None.           | .02    | 63.80                  | .0000    | .0000       | 20.95     | .0230       | .0012     | .0308            | 29.0      | .0350 |
| 14097   | Apr. 3              | None.             | V. slight.      | .00    | 65.10                  | .0000    | .0004       | 20.90     | .1400       | .0025     | .0462            | 30.0      | .0450 |
| 14263   | May 7               | None.             | None.           | .00    | 69.70                  | .0002    | .0006       | 21.70     | .0350       | .0033     | .0308            | 27.0      | .0370 |
| 14431   | June 5              | None.             | None.           | .00    | 91.80                  | .0000    | .0018       | 31.05     | .1000       | .0014     | .0418            | 40.0      | .0650 |
| 14612   | July 11             | None.             | None.           | .00    | 108.30                 | .0002    | .0008       | 38.60     | .1200       | .0013     | .0632            | 49.5      | .0600 |
| 14791   | Aug. 8              | None.             | None.           | .00    | 143.50                 | .0000    | .0010       | 47.80     | .1000       | .0015     | .1014            | 64.5      | .0100 |
| 15022   | Sept. 4             | None.             | None.           | .00    | 154.30                 | .0000    | .0010       | 57.50     | .0300       | .0013     | .0702            | 48.5      | .0340 |
| 15319   | Oct. 7              | None.             | None.           | .00    | 158.90                 | .0002    | .0000       | 64.00     | .0330       | .0015     | .0874            | 75.0      | .0070 |
| 15497   | Nov. 7              | Distinct, clayey. | Slight, earthy. | .10    | 150.20                 | .0002    | .0024       | 54.00     | .0200       | .0008     | .1232            | 66.5      | .0300 |
| 15688   | Dec. 5              | Distinct, clayey. | Cons., earthy.  | .10    | 87.20                  | .0012    | .0034       | 30.42     | .0460       | .0005     | .1030            | 43.0      | .0120 |
| Av.     | .....               | .....             | .....           | .02    | 104.73                 | .0002    | .0012       | 36.84     | .0652       | .0014     | .0663            | 45.5      | .0120 |

*Averages by Years.*

|   |       |   |   |     |        |       |       |       |       |       |       |      |       |
|---|-------|---|---|-----|--------|-------|-------|-------|-------|-------|-------|------|-------|
| - | 1887* | - | - | .00 | 22.17  | .0002 | .0016 | 3.37  | .1670 | -     | -     | -    | -     |
| - | 1888  | - | - | .00 | 22.69  | .0001 | .0022 | 3.49  | .1288 | .0022 | -     | -    | -     |
| - | 1889† | - | - | .00 | 22.72  | .0000 | .0016 | 3.28  | .1330 | .0027 | -     | -    | -     |
| - | 1890‡ | - | - | .00 | -      | .0008 | .0012 | 3.39  | .1750 | .0024 | -     | -    | -     |
| - | 1893  | - | - | .00 | 50.29  | .0002 | .0019 | 13.05 | .0907 | .0019 | .0439 | 23.0 | .0035 |
| - | 1894  | - | - | .03 | 91.99  | .0004 | .0011 | 30.80 | .0963 | .0013 | .0576 | 41.0 | .0219 |
| - | 1895  | - | - | .02 | 104.73 | .0002 | .0012 | 36.84 | .0652 | .0014 | .0663 | 45.5 | .0120 |

\* June to December.

† January to May.

‡ March.

NOTE to analyses of 1895: Odor, none. — The samples were collected from a faucet at the pumping station.

*Microscopical Examination.*

Crenothrix was found in the samples collected in January, March, April, November and December, the largest number per cubic centimeter being 576, in January.

## REVERE AND WINTHROP.

*Chemical Examination of Water from Tubular Wells of the Revere Water Company, at Cliftondale, Saugus.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Alb.-mhold. |           | Nitrates.   | Nitrites. |                  |           |       |
| 13636   | 1895.<br>Jan. 7     | None.       | None.     | .03    | 13.90                   | .0000    | .0020       | 1.26      | .1140       | .0000     | .0312            | 6.6       | .0010 |
| 13791   | Feb. 6              | None.       | None.     | .03    | 13.10                   | .0000    | .0026       | 1.25      | .1100       | .0000     | .0360            | 6.1       | .0000 |
| 13945   | Mar. 6              | None.       | None.     | .00    | 13.00                   | .0000    | .0008       | 0.85      | .1560       | .0000     | .0115            | 6.6       | .0000 |
| 14098   | Apr. 3              | None.       | None.     | .00    | 13.60                   | .0000    | .0018       | 1.18      | .1350       | .0000     | .0269            | 6.7       | .0000 |
| 14264   | May 7               | None.       | None.     | .00    | 12.90                   | .0000    | .0010       | 1.20      | .0500       | .0000     | .0000            | 6.1       | .0000 |
| 14430   | June 5              | None.       | None.     | .00    | 13.90                   | .0000    | .0020       | 1.20      | .0650       | .0001     | .0038            | 6.6       | .0000 |
| 14611   | July 11             | None.       | None.     | .00    | 13.20                   | .0014    | .0006       | 1.23      | .1100       | .0100     | .0395            | 6.0       | .0000 |
| 14792   | Aug. 8              | None.       | None.     | .00    | 14.70                   | .0012    | .0010       | 1.18      | .0750       | .0300     | .0702            | 10.5      | .0030 |
| 15021   | Sept. 4             | None.       | None.     | .00    | 13.20                   | .0000    | .0014       | 1.16      | .1250       | .0000     | .0312            | 6.4       | .0070 |
| 15318   | Oct. 7              | None.       | None.     | .00    | 12.90                   | .0006    | .0000       | 1.24      | .1100       | .0000     | .0278            | 6.9       | .0020 |
| 15496   | Nov. 8              | None.       | None.     | .02    | 15.30                   | .0002    | .0026       | 1.29      | .1000       | .0001     | .0296            | 6.6       | .0000 |
| 15657   | Dec. 4              | None.       | None.     | .02    | 13.80                   | .0000    | .0034       | 1.15      | .1200       | .0000     | .0390            | 7.4       | .0000 |
| Av.     | .....               | .....       | .....     | .01    | 13.62                   | .0003    | .0016       | 1.18      | .1058       | .0033     | .0259            | 6.9       | .0011 |

## Averages by Years.

|   |       |   |   |     |       |       |       |      |       |       |       |     |       |
|---|-------|---|---|-----|-------|-------|-------|------|-------|-------|-------|-----|-------|
| - | 1891* | - | - | .00 | 11.50 | .0018 | .0014 | 0.88 | .0100 | .0000 | -     | 5.3 | -     |
| - | 1892  | - | - | .01 | 11.65 | .0000 | .0003 | 1.16 | .0123 | .0035 | -     | 6.0 | .0116 |
| - | 1893  | - | - | .00 | 12.60 | .0002 | .0010 | 1.32 | .0872 | .0079 | .0252 | 6.4 | .0037 |
| - | 1894  | - | - | .01 | 13.08 | .0000 | .0010 | 1.24 | .0706 | .0012 | .0257 | 6.5 | .0058 |
| - | 1895  | - | - | .01 | 13.62 | .0003 | .0016 | 1.18 | .1058 | .0033 | .0259 | 6.9 | .0011 |

\* September.

NOTE to analyses of 1895: Odor, none — The samples were collected from faucets in Revere and Saugus supplied wholly from the Saugus wells.

## Microscopical Examination.

No. 13791. Fungi, *Crenothrix*, 4.

No. 14098. Fungi, *Crenothrix*, 2.

No organisms were found in the other samples.

## BEVERE AND WINTHROP.

*Chemical Examination of Water from Brooks in Saugus.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended |           |                |           |                  |           |
| 15598   | 1895.<br>Nov. 20    | V. slight.  | Slight.           | 1.10   | 3.70                            | 1.75                 | .0000    | .0182       | .0182      | .0000          | .55       | .0180          | .0001     | 0.9204           | 1.4       |
| 15599   | Nov. 20             | V. slight.  | Slight.           | 0.42   | 4.15                            | 1.90                 | .0000    | .0112       | .0098      | .0014          | .42       | .0200          | .0001     | 0.5304           | 1.1       |
| 15600   | Nov. 20             | Slight.     | Slight.           | 1.00   | 5.75                            | 2.55                 | .0006    | .0250       | .0234      | .0016          | .54       | .0200          | .0001     | 0.9245           | 1.9       |
| 15601   | Nov. 20             | Slight.     | Cons.,<br>earthy. | 1.20   | 8.20                            | 3.55                 | .0122    | .0420       | .0380      | .0040          | .97       | .0480          | .0012     | 1.3455           | 2.5       |

Odor of the first two samples, distinctly vegetable and mouldy; of the last two faintly, vegetable. — The first sample was collected from Crystal Brook, near the corner of Howard and Main streets; the second sample, from a tributary of Crystal Brook, near the corner of Howard and Main streets; the third sample, from Long Pond Brook, at the point where it crosses the Newburyport turnpike; the last sample, from a brook at the corner of Essex and Vine streets, above the point where it joins Long Pond Brook.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in these samples was as follows: No. 15598, 4; No. 15599, 155; No. 15600, 120; No. 15601, 283.

## WATER SUPPLY OF ROCKLAND.

(See *Abington.*)

## WATER SUPPLY OF ROCKPORT.

Population in 1895, 5289. The works are owned by the town and were completed in the early part of 1895. The source of supply is Cape Pond, situated in the southern part of the town. The area of the pond is 40 acres and its maximum depth is said to be about 26 feet. The pond has a watershed, including the area of the pond, of 214 acres, which contains a very small population. Water is pumped from the pond to the town and to an open iron tank, 30 feet in diameter and 60 feet in height and having a capacity of 317,000 gallons, located on Great Hill. Distributing mains are of cast iron and service pipes are of wrought iron lined with cement.

The advice of the State Board of Health to the town of Rockport relative to the use of this pond as a source of public water supply may be found on pages 45-47 of the annual report for 1893.

A further communication from the State Board of Health to the town of Rockport relative to the pollution of the water of the pond by waste matters from a glue factory may be found on page 65 of the annual report for 1894.

## ROCKPORT.

*Chemical Examination of Water from Cape Pond, Rockport.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.     |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-----------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.      | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                 |                |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13799   | 1895.<br>Feb. 12    | Distinct.       | Slight.        | .30    | 13.50                   | 1.90              | .0056    | .0264       | .0236      | .0028      | 5.40      | .0030       | .0000     | .3360            | 1.4       |
| 14293   | May 14              | Distinct.       | Cons., green.  | .25    | 11.85                   | 2.05              | .0000    | .0260       | .0164      | .0096      | 5.10      | .0030       | .0000     | .3120            | 1.4       |
| 14833   | Aug. 13             | Decided, green. | Slight, green. | .20    | 12.20                   | 2.50              | .0020    | .0434       | .0180      | .0254      | 5.70      | .0030       | .0001     | .3588            | 1.1       |
| 15536   | Nov. 12             | V. slight.      | V. slight.     | .25    | 12.90                   | 2.80              | .0024    | .0250       | .0210      | .0040      | 5.50      | .0060       | .0000     | .2902            | 1.1       |
| Av.     | 1895                | .....           | .....          | .25    | 12.61                   | 2.31              | .0025    | .0302       | .0198      | .0104      | 5.42      | .0037       | .0000     | .3242            | 1.2       |
| Av.     | 1894                | .....           | .....          | .22    | 12.85                   | 1.91              | .0001    | .0225       | .0163      | .0062      | 5.35      | .0010       | .0000     | .2455            | 1.3       |

NOTE to analyses of 1895: Odor of the second sample, none; of the others, faintly vegetable. — The samples were collected from the pond.

*Microscopical Examination of Water from Cape Pond, Rockport.*

[Number of organisms per cubic centimeter.]

|                                   | 1895. |        |       |       |
|-----------------------------------|-------|--------|-------|-------|
|                                   | Feb.  | May.   | Aug.  | Nov.  |
| Day of examination, . . . . .     | 13    | 14     | 14    | 14    |
| Number of sample, . . . . .       | 13799 | 14293  | 14833 | 15536 |
| PLANTS.                           |       |        |       |       |
| Diatomaceæ, . . . . .             | 1,000 | 37,850 | 0     | 3,368 |
| Asterionella, . . . . .           | 1,000 | 37,800 | 0     | 3,360 |
| Melosira, . . . . .               | 0     | 0      | 0     | 6     |
| Synedra, . . . . .                | 0     | 50     | 0     | 0     |
| Cyanophyceæ, Anabæna, . . . . .   | 0     | 0      | 1,300 | 0     |
| ANIMALS.                          |       |        |       |       |
| Infusoria, . . . . .              | 460   | 1,150  | 550   | 12    |
| Dinobryon, . . . . .              | 0     | 50     | 0     | 0     |
| Dinobryon cases, . . . . .        | 440   | 1,100  | 0     | 0     |
| Euglena, . . . . .                | 0     | 0      | 0     | 8     |
| Peridinium, . . . . .             | 20    | 0      | 100   | 2     |
| Trachelomonas, . . . . .          | 0     | 0      | 450   | 2     |
| Vermes, Anurea, . . . . .         | 1     | 0      | 0     | 0     |
| Crustacea, Daphnia, . . . . .     | 0     | .05    | 0     | 0     |
| Miscellaneous, Acarina, . . . . . | 0     | 0      | 0     | .02   |
| TOTAL, . . . . .                  | 1,461 | 39,000 | 1,850 | 3,378 |



## RUTLAND.

## RUTLAND.

The advice of the State Board of Health to the town of Rutland relative to taking the water of Muschopauge Lake as a public water supply may be found on page 46 of this volume. The results of the analyses of two samples of water collected from the lake are given below.

*Chemical Examination of Water from Muschopauge Lake, Rutland.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13726   | 1895.<br>Jan. 28    | None.       | V. slight. | .10    | 2.70                    | 1.10              | .0018    | .0244       | .0230      | .0014      | .24       | .0050       | .0000     | .2014            | 0.9       |
| 13968   | Mar. 12             | Slight.     | Slight.    | .15    | 2.50                    | 1.05              | .0064    | .0308       | .0286      | .0022      | .18       | .0100       | .0000     | .3696            | 0.5       |

Odor, very faintly vegetable, and in the last sample also disagreeable. The odor became stronger on heating. — The samples were collected from the lake.

*Microscopical Examination.*

No organisms were found in the first sample; in the second, an insignificant number was found.

## WATER SUPPLY OF SALEM AND BEVERLY.

The capacity of the sources of water supply of the cities of Salem and Beverly was increased in 1895 by the construction of a reservoir on Longham Brook and a conduit line to convey the water from this reservoir to Wenham Lake. The area of the Longham Brook Reservoir is 43 acres, and its capacity about 55,000,000 gallons. It is long and narrow, its length being 6,500 feet and its average width a little less than 300 feet. Its greatest depth is about 8.5 feet. The area flowed contained considerable meadow land, and was prepared for the storage of water by clearing away the trees and bushes, but the soil was not removed. The drainage area of Longham Brook, above the dam, is about 3.3 square miles, and it contains a small population.

The pipe leading from the reservoir to Wenham Lake is 36 inches in diameter and 4,900 feet in length. Its upper end is 5 feet below the high-water mark of Wenham Lake. It discharges into the lake at a point about 200 feet from the easterly shore, near the outlet, and

SALEM AND BEVERLY.

set below high water. At the time of introducing water from the Wenham Brook Reservoir into Wenham Lake, Jan. 23, 1895, the level in the lake was 19.27 feet below high-water mark, and on May 18, 1895, the reservoir became full for the first time since April 29, 1891.

Analyses of samples of water from Wenham Lake and Longham Brook Reservoir are given below.

As will be seen by the table of averages by years, the average color of the water in Wenham Lake in 1895 was much greater than in previous years.

*Chemical Examination of Water from Wenham Lake, in Beverly and Wenham.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                   |        | RESIDUE ON<br>EVAPORATION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|-------------------|--------|----------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment.         | Color. | Total.                     | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                     |                   |        |                            |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.   |                     |                     |                   |        |                            |                      |          |             |            |                 |           |                |           |                  |           |
| 627     | Jan. 8              | Slight.             | Slight.           | .20    | 7.50                       | 1.85                 | .0032    | .0152       | .0112      | .0049           | .85       | .0050          | .0000     | .1537            | 3.8       |
| 905     | Feb. 12             | V. slight.          | V. slight.        | .20    | 7.45                       | 1.70                 | .0058    | .0154       | .0134      | .0020           | .86       | .0100          | .0000     | .2000            | 3.6       |
| 960     | Mar. 11             | Slight.             | Slight.           | .15    | 7.35                       | 1.50                 | .0036    | .0122       | .0104      | .0018           | .89       | .0150          | .0000     | .2464            | 3.5       |
| 1115    | Apr. 9              | Slight.             | Cons.             | .22    | 7.05                       | 1.90                 | .0068    | .0168       | .0122      | .0046           | .77       | .0120          | .0000     | .3080            | 3.0       |
| 950     | May 13              | V. slight.          | Slight.           | .25    | 6.65                       | 1.85                 | .0024    | .0242       | .0182      | .0060           | .82       | .0050          | .0002     | .4384            | 2.7       |
| 450     | June 11             | Slight.             | Cons.             | .25    | 6.50                       | 2.50                 | .0030    | .0190       | .0168      | .0022           | .80       | .0030          | .0002     | .4290            | 3.0       |
| 630     | July 16             | Slight.             | Cons.             | .27    | 6.60                       | 2.55                 | .0010    | .0218       | .0176      | .0042           | .80       | .0070          | .0002     | .2340            | 2.9       |
| 836     | Aug 13              | Distinct,<br>green. | Slight,<br>green. | .18    | 5.80                       | 1.90                 | .0022    | .0176       | .0154      | .0022           | .82       | .0050          | .0001     | .3744            | 2.7       |
| 129     | Sept. 10            | Distinct.           | Slight.           | .25    | 6.85                       | 2.15                 | .0000    | .0172       | .0134      | .0038           | .84       | .0000          | .0001     | .3510            | 2.7       |
| 335     | Oct. 9              | V. slight.          | Slight.           | .15    | 6.70                       | 2.10                 | .0002    | .0174       | .0154      | .0020           | .79       | .0030          | .0000     | .2792            | 3.0       |
| 521     | Nov. 12             | Distinct.           | Slight.           | .20    | 6.40                       | 1.80                 | .0026    | .0190       | .0168      | .0028           | .74       | .0030          | .0001     | .2808            | 2.9       |
| 708     | Dec. 10             | Slight.             | Slight.           | .20    | 6.20                       | 1.80                 | .0034    | .0164       | .0152      | .0012           | .76       | .0030          | .0002     | .2847            | 2.9       |
| 14.     | .....               | .....               | .....             | .21    | 6.75                       | 1.97                 | .0026    | .0177       | .0146      | .0031           | .81       | .0059          | .0001     | .3033            | 3.1       |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | .05 | 4.73 | 0.82 | .0025 | .0135 | -     | -     | .72 | .0019 | -     | -     | -   |
| - | 1888  | - | - | .05 | 4.67 | 0.97 | .0020 | .0146 | -     | -     | .73 | .0058 | .0001 | -     | -   |
| - | 1889  | - | - | .06 | 4.23 | 1.05 | .0014 | .0173 | .0138 | .0035 | .72 | .0052 | .0002 | -     | -   |
| - | 1890  | - | - | .05 | 4.57 | 0.90 | .0016 | .0154 | .0125 | .0029 | .74 | .0104 | .0001 | -     | 2.5 |
| - | 1891  | - | - | .07 | 4.70 | 1.12 | .0006 | .0147 | .0113 | .0034 | .72 | .0125 | .0000 | -     | 1.9 |
| - | 1892  | - | - | .03 | 4.85 | 1.10 | .0016 | .0137 | .0103 | .0034 | .75 | .0077 | .0000 | -     | 2.2 |
| - | 1893  | - | - | .04 | 5.49 | 1.26 | .0033 | .0130 | .0100 | .0030 | .77 | .0055 | .0001 | .1605 | 2.6 |
| - | 1894  | - | - | .07 | 6.69 | 1.53 | .0030 | .0148 | .0114 | .0034 | .82 | .0023 | .0001 | .1366 | 3.0 |
| - | 1895  | - | - | .21 | 6.75 | 1.97 | .0026 | .0177 | .0146 | .0031 | .81 | .0059 | .0001 | .3033 | 3.1 |

\* June to December.

NOTE to analyses of 1895: Odor, generally vegetable, rarely none. — The first two samples were collected from faucets at the pumping station, and the others from the lake.  
For monthly record of height of water in this lake, see page 290.

## SALEM AND BEVERLY.

*Microscopical Examination of Water from Wenham Lake, in Beverly and Wenham.*

[Number of organisms per cubic centimeter.]

|                                 | 1895.        |            |            |            |              |            |            |              |            |            |              |            |
|---------------------------------|--------------|------------|------------|------------|--------------|------------|------------|--------------|------------|------------|--------------|------------|
|                                 | Jan.         | Feb.       | Mar.       | Apr.       | May.         | June       | July.      | Aug.         | Sept.      | Oct.       | Nov.         | Dec.       |
| Day of examination, . . .       | 9            | 14         | 14         | 10         | 14           | 12         | 17         | 15           | 11         | 10         | 13           | 12         |
| Number of sample, . . .         | 13627        | 13805      | 13960      | 14115      | 14290        | 14450      | 14630      | 14836        | 15129      | 15335      | 15521        | 15705      |
| <b>PLANTS.</b>                  |              |            |            |            |              |            |            |              |            |            |              |            |
| <b>Diatomaceæ, . . .</b>        | <b>1,024</b> | <b>190</b> | <b>120</b> | <b>316</b> | <b>781</b>   | <b>246</b> | <b>181</b> | <b>1,450</b> | <b>134</b> | <b>457</b> | <b>1,048</b> | <b>344</b> |
| Asterionella, . . .             | 334          | 168        | 104        | 180        | 296          | 44         | 0          | 940          | 44         | 24         | 120          | 136        |
| Cyclotella, . . .               | 28           | 17         | 12         | 20         | 264          | 100        | 0          | 2            | 0          | 8          | 0            | 68         |
| Fragilaria, . . .               | 2            | 0          | 0          | 0          | 4            | 0          | 0          | 8            | 10         | 22         | 0            | 0          |
| Melosira, . . .                 | 0            | 0          | 0          | 88         | 0            | 2          | 0          | 0            | 0          | 23         | 120          | 57         |
| Stephanodiscus, . . .           | 0            | 0          | 0          | 3          | 1            | 0          | 0          | 0            | 0          | 0          | 60           | 0          |
| Synedra, . . .                  | 0            | 1          | 0          | 2          | 0            | 2          | 1          | 0            | 0          | 0          | 0            | 19         |
| Tabellaria, . . .               | 660          | 4          | 4          | 23         | 216          | 98         | 180        | 500          | 80         | 380        | 748          | 64         |
| <b>Cyanophyceæ, . . .</b>       | <b>0</b>     | <b>0</b>   | <b>0</b>   | <b>0</b>   | <b>0</b>     | <b>9</b>   | <b>95</b>  | <b>152</b>   | <b>34</b>  | <b>57</b>  | <b>3</b>     | <b>0</b>   |
| Anabaena, . . .                 | 0            | 0          | 0          | 0          | 0            | 9          | 80         | 144          | 33         | 45         | 0            | 0          |
| Chroococcus, . . .              | 0            | 0          | 0          | 0          | 0            | 0          | 0          | 0            | 0          | 7          | 2            | 0          |
| Clothrocystis, . . .            | 0            | 0          | 0          | 0          | 0            | 0          | 11         | 8            | 1          | 0          | 0            | 0          |
| Cælospherium, . . .             | 0            | 0          | 0          | 0          | 0            | 0          | 4          | 0            | 0          | 5          | 1            | 0          |
| <b>Algæ, . . .</b>              | <b>9</b>     | <b>0</b>   | <b>0</b>   | <b>1</b>   | <b>8</b>     | <b>36</b>  | <b>281</b> | <b>7</b>     | <b>74</b>  | <b>37</b>  | <b>6</b>     | <b>13</b>  |
| Chlorococcus, . . .             | 0            | 0          | 0          | 0          | 0            | 0          | 0          | 0            | 2          | 5          | 5            | 0          |
| Celastrum, . . .                | 0            | 0          | 0          | 0          | 0            | 0          | 0          | 0            | 0          | 0          | 0            | 12         |
| Protooccus, . . .               | 9            | 0          | 0          | 0          | 0            | 0          | 280        | 7            | 70         | 30         | 0            | 0          |
| Raphidium, . . .                | 0            | 0          | 0          | 0          | 8            | 35         | 1          | 0            | 0          | 0          | 1            | 1          |
| Staurostrum, . . .              | 0            | 0          | 0          | 1          | 0            | 1          | 0          | 0            | 2          | 2          | 0            | 0          |
| <b>Fungi, Crenothrix, . . .</b> | <b>0</b>     | <b>0</b>   | <b>0</b>   | <b>76</b>  | <b>0</b>     | <b>3</b>   | <b>0</b>   | <b>0</b>     | <b>0</b>   | <b>0</b>   | <b>0</b>     | <b>0</b>   |
| <b>ANIMALS.</b>                 |              |            |            |            |              |            |            |              |            |            |              |            |
| <b>Rhizopoda, Diffugia, . .</b> | <b>0</b>     | <b>0</b>   | <b>0</b>   | <b>2</b>   | <b>0</b>     | <b>0</b>   | <b>0</b>   | <b>0</b>     | <b>0</b>   | <b>0</b>   | <b>0</b>     | <b>0</b>   |
| <b>Infusoria, . . .</b>         | <b>2</b>     | <b>9</b>   | <b>5</b>   | <b>17</b>  | <b>211</b>   | <b>44</b>  | <b>108</b> | <b>0</b>     | <b>16</b>  | <b>102</b> | <b>31</b>    | <b>2</b>   |
| Dinobryon, . . .                | 0            | 0          | 0          | 0          | 0            | 40         | 80         | 0            | 0          | 90         | 0            | 0          |
| Dinobryon casca, . . .          | 0            | 3          | 2          | 7          | 204          | 3          | 28         | 0            | 16         | 5          | 0            | 0          |
| Mallomonas, . . .               | 0            | 0          | 0          | 1          | 0            | 0          | 0          | 0            | 0          | 5          | 2            | 0          |
| Monas, . . .                    | pr.          | 0          | 0          | 1          | 0            | 0          | 0          | 0            | 0          | 0          | 0            | 0          |
| Peridinium, . . .               | 0            | 0          | 1          | 3          | 1            | 0          | 0          | 0            | 0          | 0          | 1            | 0          |
| Trachelomonas, . . .            | 2            | 6          | 2          | 6          | 6            | 1          | 0          | 0            | 0          | 2          | 28           | 2          |
| <b>Vermes, . . .</b>            | <b>0</b>     | <b>0</b>   | <b>0</b>   | <b>1</b>   | <b>1</b>     | <b>0</b>   | <b>0</b>   | <b>0</b>     | <b>1</b>   | <b>1</b>   | <b>1</b>     | <b>0</b>   |
| Anurea, . . .                   | 0            | 0          | 0          | 1          | 0            | 0          | 0          | 0            | 1          | 0          | 1            | 0          |
| Rotatorian ova, . . .           | 0            | 0          | 0          | 0          | 1            | 0          | 0          | 0            | 0          | 1          | 0            | 0          |
| <b>Miscellaneous, . . .</b>     | <b>0</b>     | <b>0</b>   | <b>0</b>   | <b>0</b>   | <b>0</b>     | <b>0</b>   | <b>.08</b> | <b>.04</b>   | <b>0</b>   | <b>0</b>   | <b>8</b>     | <b>0</b>   |
| Acarina, . . .                  | 0            | 0          | 0          | 0          | 0            | 0          | .08        | .04          | 0          | 0          | .02          | 0          |
| Zoöglen, . . .                  | 0            | 0          | 0          | 0          | 0            | 0          | 0          | 0            | 0          | 0          | 5            | 0          |
| <b>TOTAL, . . .</b>             | <b>1,035</b> | <b>199</b> | <b>125</b> | <b>413</b> | <b>1,001</b> | <b>338</b> | <b>665</b> | <b>1,609</b> | <b>259</b> | <b>654</b> | <b>1,097</b> | <b>359</b> |

SALEM AND BEVERLY.

*Chemical Examination of Water from Longham Brook Reservoir, in Beverly and Wenham.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.          |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|----------------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.           | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                      |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 55      | 1895.<br>Jan. 14    | V. slight.           | V. slight. | 1.00   | 5.10                            | 3.20                 | .0074    | .0270       | .0254      | .0016           | .89       | .0080          | .0000     | 0.8966           | 1.3       |
| 04      | Feb. 12             | V. slight.           | Slight.    | 1.35   | 6.95                            | 2.40                 | .0102    | .0226       | .0212      | .0014           | .99       | .0220          | .0001     | 1.2800           | 1.9       |
| 50      | Mar. 11             | Distinct,<br>clayey. | Cons.      | 0.80   | 4.95                            | 2.20                 | .0184    | .0256       | .0268      | .0018           | .58       | .0100          | .0001     | 0.9317           | 1.3       |
| 14      | Apr. 9              | Distinct,<br>milky.  | Cons.      | 0.83   | 4.90                            | 2.20                 | .0008    | .0320       | .0288      | .0032           | .69       | .0080          | .0001     | 0.8431           | 1.1       |
| 289     | May 13              | Slight.              | Cons.,     | 2.40   | 8.20                            | 4.25                 | .0020    | .0572       | .0484      | .0088           | .92       | .0050          | .0000     | 2.2910           | 2.1       |
| LV.     | .....               | .....                | .....      | 1.28   | 6.02                            | 2.85                 | .0074    | .0335       | .0301      | .0034           | .81       | .0106          | .0001     | 1.0485           | 1.5       |

Odor, vegetable and generally unpleasant. — The first and last two samples were collected from the reservoir, and the others from the 36-inch pipe which conveys water from this reservoir to Wenham lake.

*Microscopical Examination of Water from Longham Brook Reservoir, in Beverly and Wenham.*

[Number of organisms per cubic centimeter.]

|                               | 1895. |       |       |       |       |
|-------------------------------|-------|-------|-------|-------|-------|
|                               | Jan.  | Feb.  | Mar.  | Apr.  | May.  |
| Day of examination, . . . . . | 15    | 14    | 13    | 10    | 14    |
| Number of sample, . . . . .   | 13655 | 13904 | 13959 | 14114 | 14289 |
| PLANTS.                       |       |       |       |       |       |
| Diatomaceæ, . . . . .         | 6     | 11    | 1     | 32    | 158   |
| Asterionella, . . . . .       | 3     | 1     | 0     | 0     | 0     |
| Ephthemia, . . . . .          | 0     | 1     | 0     | 1     | 4     |
| Gomphonema, . . . . .         | 0     | 0     | 0     | 8     | 0     |
| Melosira, . . . . .           | 0     | 0     | 0     | 4     | 0     |
| Meridion, . . . . .           | 3     | 4     | 1     | 12    | 0     |
| Navicula, . . . . .           | 0     | pr.   | 0     | 0     | 2     |
| Synedra, . . . . .            | 0     | 3     | 0     | 11    | 152   |
| Tabellaria, . . . . .         | 0     | 2     | 0     | 1     | 0     |
| Algae, Zoospores, . . . . .   | 0     | 0     | 2     | 8     | 0     |
| Fungi, . . . . .              | 2     | 1     | 1,025 | 6     | 4,800 |
| Cladothrix, . . . . .         | 0     | 0     | 25    | 0     | 0     |
| Crenothrix, . . . . .         | 2     | 1     | 0     | 6     | 4,800 |
| Molds, . . . . .              | 0     | 0     | 1,000 | 0     | 0     |

## SALEM AND BEVERLY.

*Microscopical Examination of Water from Longham Brook Reservoir, in Beverly and Wenham — Concluded.*

[Number of organisms per cubic centimeter.]

|                                          | 1895.     |           |              |           |              |
|------------------------------------------|-----------|-----------|--------------|-----------|--------------|
|                                          | Jan.      | Feb.      | Mar.         | Apr.      | May.         |
| <b>ANIMALS.</b>                          |           |           |              |           |              |
| <b>Infusoria, . . . . .</b>              | <b>4</b>  | <b>1</b>  | <b>0</b>     | <b>14</b> | <b>44</b>    |
| Ciliated infusorian, . . . . .           | 0         | 0         | 0            | 0         | 2            |
| Dinobryon, . . . . .                     | 0         | 0         | 0            | 8         | 14           |
| Euglena, . . . . .                       | 1         | 0         | 0            | 0         | 0            |
| Monas, . . . . .                         | 0         | 0         | 0            | 2         | 0            |
| Peridinium, . . . . .                    | 8         | 1         | 0            | 1         | 14           |
| Synura, . . . . .                        | 0         | 0         | 0            | 3         | 0            |
| Trachelomonas, . . . . .                 | 0         | 0         | 0            | 0         | 14           |
| <b>Miscellaneous, Zoöglæa, . . . . .</b> | <b>0</b>  | <b>36</b> | <b>0</b>     | <b>0</b>  | <b>0</b>     |
| <b>TOTAL, . . . . .</b>                  | <b>12</b> | <b>49</b> | <b>1,028</b> | <b>60</b> | <b>5,002</b> |

Table showing Heights of Water in Wenham Lake on the First of Each Month in 1895.

[NOTE. — High-water mark is 30 17 feet.]

| DATE.              |  | Height of Water. | DATE.              |  | Height of Water. |
|--------------------|--|------------------|--------------------|--|------------------|
| <b>1895.</b>       |  | <b>Feet.</b>     | <b>1895.</b>       |  | <b>Feet.</b>     |
| Jan. 1, . . . . .  |  | 19.17            | July 1, . . . . .  |  | 28.90            |
| Feb. 1, . . . . .  |  | 21.56            | Aug. 1, . . . . .  |  | 27.98            |
| March 1, . . . . . |  | 22.21            | Sept. 1, . . . . . |  | 27.08            |
| April 1, . . . . . |  | 26.73            | Oct. 1, . . . . .  |  | 26.04            |
| May 1, . . . . .   |  | 29.50            | Nov. 1, . . . . .  |  | 26.03            |
| June 1, . . . . .  |  | 29.79            | Dec. 1, . . . . .  |  | 27.50            |

## WATER SUPPLY OF SAUGUS.

(See Lynn.)

## SHARON.

## WATER SUPPLY OF SHARON.

The works of the Sharon Water Company were purchased by the town Oct. 3, 1895.

*Chemical Examination of Water from the Well of the Sharon Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | 1895.               |             |           |        |                         |          |             |           |             |           |                  |           |       |
| 14545   | June 26             | None.       | None.     | .00    | 10.00                   | .0004    | .0002       | .97       | .1840       | .0000     | .0000            | 2.9       | .0000 |
| 14581   | July 8              | None.       | None.     | .00    | 8.70                    | .0000    | .0000       | .98       | .2000       | .0000     | .0000            | 3.1       | .0000 |

*Averages by Years.*

|   |       |   |   |     |       |       |       |      |       |       |       |     |       |
|---|-------|---|---|-----|-------|-------|-------|------|-------|-------|-------|-----|-------|
| - | 1887* | - | - | .00 | 8.30  | .0000 | .0006 | 0.85 | .1709 | -     | -     | -   | -     |
| - | 1888† | - | - | .00 | 7.55  | .0001 | .0008 | 0.81 | .2130 | .0001 | -     | -   | -     |
| - | 1892‡ | - | - | .00 | 8.45  | .0000 | .0001 | 0.94 | .2500 | .0000 | -     | 2.9 | .0000 |
| - | 1893§ | - | - | .00 | 10.70 | .0000 | .0000 | 0.91 | .3750 | .0000 | .0158 | 2.8 | .0100 |
| - | 1894  | - | - | .00 | 9.20  | .0000 | .0000 | 1.00 | .2500 | .0000 | .0000 | 3.0 | .0200 |
| - | 1895¶ | - | - | .00 | 9.35  | .0002 | .0001 | 0.98 | .1920 | .0000 | .0000 | 3.0 | .0000 |

\* June to December.

† January to May.

‡ March and September.

§ August.

|| July.

¶ June and July.

NOTE to analyses of 1895: Odor, none. — The samples were collected from a faucet at the pumping station while pumping.

*Microscopical Examination.*

No organisms were found in the first sample; in the last sample an insignificant number was found.

**SHEFFIELD.****SHEFFIELD.**

The advice of the State Board of Health to H. S. Andrews and others, of Sheffield, relative to taking the water of certain springs in that town for a public water supply may be found on page 46 of this volume. The analyses of samples of water collected during the investigation of the proposed sources of supply are given below.

*Chemical Examination of Water from Various Sources in Sheffield.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 13583   | 1894.<br>Dec. 31    | None.       | Cons.             | .00    | 3.05                            | 0.40                 | .0002    | .0026       | .0016      | .0010           | .07       | .0030          | .0000     | .0000            | 1.7       |
| 13617   | 1895.<br>Jan. 7     | Slight.     | Cons.,<br>earthy. | .25    | 3.70                            | 1.20                 | .0000    | .0204       | .0038      | .0166           | .00       | .0030          | .0000     | .2223            | 1.6       |
| 13618   | Jan. 7              | Slight.     | Cons.,<br>earthy. | .20    | 4.75                            | 1.10                 | .0008    | .0188       | .0068      | .0120           | .10       | .0070          | .0000     | .2184            | 2.9       |
| 13616   | Jan. 7              | Slight.     | Cons.,<br>earthy. | .50    | 7.90                            | 2.10                 | .0034    | .0224       | .0160      | .0064           | .12       | .0080          | .0000     | .5499            | 4.7       |
| 13615   | Jan. 7              | V. slight.  | Cons.             | .75    | 7.95                            | 2.60                 | .0058    | .0252       | .0236      | .0016           | .13       | .0180          | .0001     | .7839            | 4.7       |

Odor of the first sample, none; of the others, very faintly vegetable. On heating, the odor of No. 13615 became decidedly vegetable and unpleasant. — The samples were collected as follows: No. 13583, from Smith's spring, near the junction of two brooks above the road from Sheffield to Hartsville; No. 13617, from Clark's Brook, just below the junction of three small brooks, a short distance north of Smith's spring; No. 13618, from Pool Brook, below the springs and just above the road to Hartsville; No. 13616, from Iron Brook, just above Three-mile Pond; No. 13615, from Iron Brook, below Three-mile Pond and just below a small mill-pond furnishing power for a saw-mill.

*Microscopical Examination.*

The total number of organisms per cubic centimeter found in these samples was as follows: No. 13583, 1; No. 13617, 19; No. 13618, 18; No. 13616, 24; No. 13615, 55.

**SHIRLEY.**

The advice of the State Board of Health to the town of Shirley relative to taking water from Leatherboard Pond in that town as a public water supply may be found on pages 46 and 47 of this volume. The results of analyses of samples of water from several sources in the town, collected during the investigation of proposed sources of supply, are given below.

## SHIRLEY.

*1 Examination of Water from Turner's Pond, Fort Pond, Bow Brook and the Shirley Reservoir.*

[Parts per 100,000.]

|    | APPEARANCE. |                    |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |           |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed | Hardness. |
|----|-------------|--------------------|--------|---------------------------------|----------------------|----------|-------------|-----------|-----------------|-----------|----------------|-----------|-----------------|-----------|
|    | Turbidity.  | Sediment.          | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |           |                 |           | Nitrates.      | Nitrites. |                 |           |
|    |             |                    |        |                                 |                      |          | Total.      | Dissolved | Sus-<br>pended. |           |                |           |                 |           |
| 5. |             |                    |        |                                 |                      |          |             |           |                 |           |                |           |                 |           |
| 13 | Distinct.   | Cons.,<br>fibrous. | .15    | 1.60                            | 1.10                 | .0008    | .0360       | .0306     | .0054           | .14       | .0060          | .0001     | .4095           | 0.0       |
| 13 | Distinct.   | Slight,<br>green.  | .12    | 3.45                            | 1.60                 | .0036    | .0284       | .0134     | .0150           | .19       | .0050          | .0000     | .1950           | 0.9       |
| 13 | Distinct.   | Slight,<br>green.  | .30    | 3.65                            | 1.10                 | .0010    | .0140       | .0120     | .0020           | .19       | .0050          | .0001     | .3744           | 1.1       |
| 13 | Distinct.   | Slight.            | .48    | 4.35                            | 1.85                 | .0002    | .0152       | .0118     | .0034           | .19       | .0030          | .0000     | .5086           | 0.9       |
| 8  | Distinct.   | Slight.            | .07    | 4.35                            | 1.95                 | .0056    | .0242       | .0202     | .0040           | .24       | .0000          | .0000     | .7722           | 1.3       |

f the first three and last samples, faintly vegetable; of the fourth sample, distinctly vegetable y. — The samples were collected as follows: No. 15542, from Turner's Pond, near the easterly . 15545, from Fort Pond, at its outlet; No. 15543, from Bow Brook, about a mile below Turner's just above Leatherboard Pond; No. 15544, from Leatherboard Pond, a small mill-pond on Bow its outlet; No. 15563, from Shirley reservoir, near the dam.

*pical Examination of Water from Turner's Pond, Fort Pond, Bow Brook and the Shirley Reservoir.*

[Number of organisms per cubic centimeter.]

|                              | 1895. |       |       |       |       |
|------------------------------|-------|-------|-------|-------|-------|
|                              | Nov.  | Nov.  | Nov.  | Nov.  | Dec.  |
| mination, . . . . .          | 15    | 15    | 15    | 16    | 4     |
| f sample, . . . . .          | 15542 | 15545 | 15543 | 15544 | 15563 |
| PLANTS.                      |       |       |       |       |       |
| loose, . . . . .             | 2     | 684   | 164   | 13    | 51    |
| onella, . . . . .            | 0     | 4     | 2     | 0     | 21    |
| ella, . . . . .              | 2     | 36    | 0     | 0     | 0     |
| na, . . . . .                | 0     | 1     | 0     | 6     | 0     |
| aria, . . . . .              | 0     | 0     | 0     | 2     | 0     |
| ra, . . . . .                | 0     | 640   | 160   | 0     | 0     |
| ila, . . . . .               | 0     | 0     | 1     | 0     | 1     |
| ra, . . . . .                | 0     | 0     | 0     | 5     | 27    |
| aria, . . . . .              | 0     | 8     | 0     | 0     | 2     |
| hycos, Oscillaria, . . . . . | 0     | 1,160 | 0     | 0     | 0     |
| . . . . .                    | 52    | 0     | 594   | 1     | 1     |
| desmus, . . . . .            | 8     | 0     | 0     | 1     | 0     |
| nocous, . . . . .            | 14    | 0     | 0     | 0     | 0     |
| rva, . . . . .               | 0     | 0     | 584   | 0     | 0     |
| dium, . . . . .              | 24    | 0     | 0     | 0     | 1     |
| gra, . . . . .               | 2     | 0     | 0     | 0     | 0     |
| strum, . . . . .             | 4     | 0     | 0     | 0     | 0     |
| hemothrix, . . . . .         | 0     | 2     | 1     | 0     | 1     |



**SHIRLEY.***Microscopical Examination of Water from Turner's Pond, Fort Pond, Bow Brook and the Shirley Reservoir — Concluded.*

[Number of organisms per cubic centimeter.]

|                                   | 1895.      |              |            |           |            |
|-----------------------------------|------------|--------------|------------|-----------|------------|
|                                   | Nov.       | Nov.         | Nov.       | Nov.      | Dec.       |
| <b>ANIMALS.</b>                   |            |              |            |           |            |
| Infusoria, . . . . .              | 2          | 0            | 0          | 48        | 307        |
| Dinobryon, . . . . .              | 0          | 0            | 0          | 0         | 308        |
| Dinobryon cases, . . . . .        | 2          | 0            | 0          | 48        | 0          |
| Mallomonas, . . . . .             | 0          | 0            | 0          | 0         | 1          |
| Miscellaneous, Zoöglon, . . . . . | 120        | 80           | 0          | 0         | 0          |
| <b>TOTAL, . . . . .</b>           | <b>176</b> | <b>1,926</b> | <b>749</b> | <b>62</b> | <b>360</b> |

**WATER SUPPLY OF SOMERVILLE.**

(See Boston, Mystic Works.)

*Chemical Examination of Water from a Spring at Winter Hill, Somerville.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 13926   | 1895.<br>Mar. 5     | None.       | None.     | .00    | 25.80                   | .0000    | .0002       | 2.20      | .5500       | .0000     | .0269            | 15.2      | .0000 |

Odor, none. — The sample was collected from an iron pipe set in a spring near the Winter Hill station on the Boston & Maine Railroad in Somerville.

*Microscopical Examination.*

No organisms.

**SPENCER.***Chemical Examination of Water from a Stream flowing from Brook's Pond, Spencer.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |        |            |           | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|--------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Total. | Dissolved. | Subsided. | Chlorine.   | Nitrates. | Nitrites.        |           |
| 14360   | 1895.<br>May 23     | Distinct.   | Slight.   | .30    | 2.60                    | 0.85              | .0004    | .0158  | .0114      | .0044     | .17         | .0000     | .0000            | .4279 0.9 |

Odor, very faintly vegetable, becoming much stronger on heating.

*Microscopical Examination.*

Diatomaceæ, *Asterionella*, 16; *Cyclotella*, 3; *Himantidium*, 1; *Melosira*, 35; *Synedra*, 3; *Tabellaria*, 160. Cyanophycæ, *Anabæna*, 7. Algæ, *Arthrodesmus*, 1; *Raphidium*, 4; *Scenedesmus*, 1. Infusoria, *Dinobryon* cases, 96; *Peridinium*, 1; *Trachelomonas*, 1; *Vorticella*, 3. Vermes, *Polyarthra*, 1. Total, 833.

SPRINGFIELD.

WATER SUPPLY OF SPRINGFIELD.

*nical Examination of Water from the Receiving Basin of the Springfield Water Works, at Ludlow.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE.        |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------------------|--------------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                     | Turbidity.         | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|                     |                    |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.               |                    |                   |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| Jan. 10             | Slight.            | V. slight.        | .60    | 4.00                            | 1.80                 | .0022    | .0162       | .0156      | .0006           | .19       | .0080          | .0002     | .5304            | 1.6       |
| Feb. 11             | Slight.            | Slight.           | .35    | 3.85                            | 1.50                 | .0068    | .0182       | .0158      | .0024           | .21       | .0070          | .0000     | .4240            | 1.4       |
| Mar. 11             | Slight.            | Slight.           | .45    | 3.90                            | 1.60                 | .0034    | .0172       | .0148      | .0024           | .17       | .0100          | .0000     | .5043            | 0.8       |
| Apr. 8              | Slight.            | Slight.           | .50    | 3.50                            | 1.45                 | .0016    | .0156       | .0120      | .0036           | .14       | .0050          | .0000     | .4759            | 0.9       |
| May 8               | Distinct.          | Cons.             | .55    | 3.75                            | 1.65                 | .0010    | .0172       | .0128      | .0044           | .15       | .0000          | .0000     | .5120            | 1.4       |
| June 10             | Slight.            | Cons.             | .63    | 4.05                            | 2.05                 | .0016    | .0238       | .0218      | .0020           | .12       | .0050          | .0003     | .6384            | 1.4       |
| July 15             | Slight.            | Cons.             | .50    | 3.95                            | 1.60                 | .0016    | .0226       | .0194      | .0032           | .16       | .0070          | .0000     | .4914            | 1.5       |
| Aug. 12             | Slight.            | Cons.,<br>brown.  | .30    | 3.70                            | 1.75                 | .0016    | .0204       | .0150      | .0054           | .20       | .0000          | .0000     | .3900            | 1.6       |
| Sept. 9             | Decided,<br>green. | Cons.,<br>green.  | .25    | 3.65                            | 1.20                 | .0002    | .0346       | .0198      | .0148           | .19       | .0000          | .0000     | .3237            | 1.9       |
| Oct. 9              | V. slight.         | Slight,<br>green. | .30    | 3.95                            | 1.60                 | .0004    | .0366       | .0198      | .0168           | .22       | .0050          | .0000     | .4306            | 1.4       |
| Nov. 11             | Slight.            | Slight.           | .75    | 4.75                            | 2.00                 | .0012    | .0198       | .0164      | .0034           | .28       | .0100          | .0000     | .7293            | 1.4       |
| Dec. 9              | V. slight.         | V. slight.        | .50    | 3.25                            | 1.10                 | .0008    | .0128       | .0114      | .0014           | .12       | .0030          | .0000     | .5132            | 0.9       |
| .....               | .....              | .....             | .47    | 3.86                            | 1.61                 | .0019    | .0212       | .0162      | .0050           | .18       | .0050          | .0000     | .4969            | 1.3       |

*Averages by Years.*

|      |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| 1891 | - | - | .31 | 3.27 | 1.20 | .0011 | .0225 | .0147 | .0078 | .09 | .0049 | .0001 | -     | 1.0 |
| 1892 | - | - | .44 | 3.79 | 1.39 | .0004 | .0164 | .0127 | .0037 | .14 | .0089 | .0001 | -     | 1.3 |
| 1893 | - | - | .40 | 3.76 | 1.39 | .0009 | .0204 | .0146 | .0058 | .15 | .0026 | .0001 | .5132 | 1.2 |
| 1894 | - | - | .49 | 3.68 | 1.42 | .0010 | .0196 | .0151 | .0045 | .16 | .0027 | .0000 | .4635 | 1.6 |
| 1895 | - | - | .47 | 3.86 | 1.61 | .0019 | .0212 | .0182 | .0050 | .18 | .0050 | .0000 | .4969 | 1.3 |

**NOTE** to analyses of 1895: Odor, vegetable, occasionally mouldy. — The samples were collected in **gate-house**. A portion of the water received into this basin comes from Ludlow Reservoir.

## SPRINGFIELD.

*Microscopical Examination of Water from the Receiving Basin of the Springfield Water Works at Ludlow.*

[Number of organisms per cubic centimeter.]

|                                | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|--------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .      | 11    | 13    | 13    | 9     | 9     | 11    | 16    | 13    | 11    | 10    | 13    | 10    |
| Number of sample, . . .        | 13639 | 13796 | 13953 | 14108 | 14268 | 14445 | 14620 | 14811 | 15106 | 15337 | 15510 | 15694 |
| PLANTS.                        |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .              | 7     | 28    | 19    | 36    | 210   | 121   | 378   | 160   | 629   | 900   | 60    | 19    |
| Asterionella, . . .            | 0     | 20    | 8     | 5     | 17    | 13    | 6     | 20    | 8     | 0     | 20    | 0     |
| Cocconeia, . . .               | 0     | 0     | 0     | 0     | 7     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Cyclotella, . . .              | 0     | 0     | 0     | 1     | 0     | 1     | 4     | 0     | 4     | 0     | 0     | 0     |
| Cymbella, . . .                | 0     | 0     | 0     | 1     | 2     | 1     | 5     | 0     | 12    | 0     | 2     | 0     |
| Fragilaria, . . .              | 0     | 0     | 0     | 0     | 0     | 0     | 320   | 100   | 524   | 900   | 2     | 5     |
| Melosira, . . .                | 0     | 3     | 4     | 12    | 125   | 38    | 20    | 30    | 47    | 0     | 18    | 0     |
| Meridion, . . .                | 2     | 0     | 0     | 4     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     |
| Navicula, . . .                | 1     | 0     | 2     | 2     | 9     | 8     | 13    | 4     | 6     | 0     | 6     | 2     |
| Surirella, . . .               | 1     | 1     | 0     | 0     | 2     | 2     | 0     | 0     | 1     | 0     | 0     | 1     |
| Synedra, . . .                 | 2     | 2     | 4     | 10    | 48    | 48    | 8     | 4     | 2     | 0     | 7     | 4     |
| Tabellaria, . . .              | 1     | 0     | 1     | 1     | 0     | 10    | 2     | 2     | 25    | 0     | 5     | 6     |
| Cyanophyceæ, . . .             | 0     | 0     | 0     | 0     | 0     | 6     | 0     | 14    | 456   | 1,800 | 0     | 0     |
| Anabaena, . . .                | 0     | 0     | 0     | 0     | 0     | 6     | 0     | 14    | 450   | 1,050 | 0     | 0     |
| Chroococcus, . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 6     | 750   | 0     | 0     |
| Algæ, . . .                    | 0     | 1     | 5     | 3     | 18    | 8     | 61    | 382   | 370   | 100   | 6     | 0     |
| Chlorococcus, . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 180   | 0     | 8     | 0     |
| Celastrum, . . .               | 0     | 0     | 0     | 0     | 0     | 0     | 36    | 0     | 0     | 0     | 0     | 0     |
| Desmidiium, . . .              | 0     | 0     | 0     | 0     | 6     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Gloeocapsa, . . .              | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 68    | 0     | 0     | 0     | 0     |
| Pediastrum, . . .              | 0     | 0     | 0     | 0     | 5     | 0     | 2     | 4     | 2     | 0     | 0     | 0     |
| Protooccus, . . .              | 0     | 0     | 0     | 0     | 0     | 0     | 15    | 250   | 0     | 0     | 0     | 0     |
| Raphidium, . . .               | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 12    | 12    | 0     | 0     | 0     |
| Scenedesmus, . . .             | 0     | 1     | 0     | 0     | 4     | 1     | 1     | 32    | 4     | 50    | 1     | 0     |
| Staurostrum, . . .             | 0     | 0     | 0     | 0     | 0     | 7     | 4     | 6     | 8     | 50    | 0     | 0     |
| Staurogenia, . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 164   | 0     | 0     | 0     |
| Zoospores, . . .               | 0     | 0     | 5     | 3     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Fungi, Crenothrix, . . .       | 2     | 0     | 1     | 0     | 1     | 0     | 0     | 1     | 0     | 0     | 9     | 0     |
| ANIMALS.                       |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . .               | 1     | 78    | 43    | 120   | 258   | 1     | 94    | 26    | 66    | 0     | 3     | 0     |
| Bursaria, . . .                | 0     | 50    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon, . . .               | 0     | 7     | 1     | 24    | 0     | 0     | 74    | 0     | 30    | 0     | 0     | 0     |
| Dinobryon cases, . . .         | 0     | 0     | 32    | 84    | 256   | 0     | 0     | 6     | 0     | 0     | 0     | 0     |
| Mallomonas, . . .              | 0     | 0     | 0     | 1     | 0     | 1     | 0     | 11    | 0     | 0     | 0     | 0     |
| Peridinium, . . .              | 1     | 0     | 10    | 11    | 1     | 0     | 0     | 4     | 0     | 0     | 1     | 0     |
| Trachelomonas, . . .           | 0     | 1     | 0     | 0     | 1     | 0     | 20    | 5     | 36    | 0     | 2     | 0     |
| Uroglena, . . .                | 0     | 20    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Vermes, . . .                  | 0     | 10    | 1     | 0     | 2     | 1     | 0     | 0     | 2     | 0     | 0     | 0     |
| Anurea, . . .                  | 0     | 10    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Rotatorian ova, . . .          | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     |
| Rotifer, . . .                 | 0     | 0     | 1     | 0     | 2     | 1     | 0     | 0     | 0     | 0     | 0     | 0     |
| Miscellaneous, Zoöglenæ, . . . | 0     | 0     | 56    | 0     | 316   | 0     | 0     | 30    | 0     | 0     | 100   | 0     |
| TOTAL, . . .                   | 10    | 115   | 125   | 150   | 805   | 137   | 533   | 613   | 1,523 | 2,800 | 178   | 19    |

## SPRINGFIELD.

*Chemical Examination of Water from Ludlow Reservoir.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|-------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment.         | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                     |                   |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.   |                     |                     |                   |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 13611   | Jan. 7              | Slight.             | Slight.           | .43    | 3.65                    | 1.55              | .0016    | .0296       | .0240      | .0056      | .20       | .0000       | .0000     | .4407            | 1.3       |
| 13710   | Jan. 24             | Slight.             | Slight.           | .40    | 3.40                    | 1.65              | .0012    | .0308       | .0246      | .0062      | .23       | .0030       | .0000     | .5174            | 0.9       |
| 13798   | Feb. 11             | Slight.             | Slight.           | .42    | 4.10                    | 1.60              | .0132    | .0308       | .0258      | .0050      | .23       | .0030       | .0000     | .5824            | 1.4       |
| 13952   | Mar. 11             | Slight.<br>green.   | Slight.           | .25    | 2.95                    | 1.10              | .0058    | .0214       | .0130      | .0084      | .15       | .0070       | .0000     | .3503            | 0.8       |
| 14107   | Apr. 8              | Slight.             | Slight.           | .28    | 3.40                    | 1.50              | .0052    | .0224       | .0176      | .0048      | .15       | .0030       | .0000     | .3811            | 1.1       |
| 14267   | May 8               | Slight.             | Cons.             | .20    | 3.15                    | 1.70              | .0004    | .0188       | .0166      | .0020      | .16       | .0000       | .0000     | .3411            | 1.1       |
| 14444   | June 10             | Slight.             | Cons.             | .25    | 3.10                    | 1.60              | .0016    | .0220       | .0188      | .0032      | .17       | .0030       | .0000     | .4028            | 0.9       |
| 14619   | July 15             | Slight.             | Cons.             | .28    | 3.10                    | 1.90              | .0000    | .0266       | .0186      | .0080      | .15       | .0070       | .0000     | .3744            | 1.1       |
| 14705   | July 24             | Distinct.           | Cons.<br>green.   | .40    | 3.20                    | 1.20              | .0004    | .0232       | .0162      | .0070      | .23       | .0030       | .0000     | .3773            | 1.3       |
| 14810   | Aug. 12             | Distinct.<br>green. | Cons.<br>green.   | .23    | 3.30                    | 1.70              | .0012    | .0250       | .0198      | .0052      | .18       | .0020       | .0000     | .2340            | 1.4       |
| 14923   | Aug. 28             | V. slight.          | Cons.             | .18    | 3.35                    | 1.65              | .0010    | .0250       | .0188      | .0062      | .20       | .0030       | .0000     | .3276            | 1.2       |
| 15108   | Sept. 9             | Decided.<br>green.  | Cons.<br>green.   | .20    | 3.60                    | 1.45              | .0000    | .0440       | .0224      | .0216      | .21       | .0000       | .0000     | .3994            | 1.3       |
| 15232   | Sept. 23            | Slight.             | Cons.<br>green.   | .23    | 3.25                    | 1.60              | .0022    | .0416       | .0244      | .0172      | .18       | .0070       | .0000     | .4524            | 0.8       |
| 15336   | Oct. 9              | Distinct.           | Slight.<br>green. | .20    | 3.10                    | 1.45              | .0000    | .0714       | .0212      | .0502      | .18       | .0000       | .0000     | .3900            | 1.3       |
| 15412   | Oct. 22             | Decided.<br>green.  | Cons.<br>green.   | .23    | 3.20                    | 1.80              | .0000    | .0582       | .0232      | .0350      | .20       | .0030       | .0000     | .4017            | 0.8       |
| 15509   | Nov. 11             | Distinct.<br>green. | Cons.<br>yellow.  | .30    | 3.75                    | 1.60              | .0016    | .0486       | .0242      | .0244      | .30       | .0050       | .0000     | .4976            | 1.1       |
| 15609   | Nov. 25             | Decided.<br>green.  | Slight.           | .35    | 3.15                    | 1.65              | .0002    | .0400       | .0208      | .0192      | .15       | .0030       | .0001     | .4992            | 1.1       |
| 15695   | Dec. 9              | Slight.             | Slight.           | .38    | 3.55                    | 1.60              | .0010    | .0344       | .0218      | .0126      | .13       | .0030       | .0001     | .4914            | 0.9       |
| 15799   | Dec. 23             | Distinct.           | Slight.           | .36    | 3.35                    | 1.50              | .0048    | .0276       | .0180      | .0096      | .15       | .0000       | .0000     | .4350            | 0.9       |
| Av.*    | .....               | .....               | .....             | .29    | 3.35                    | 1.55              | .0028    | .0315       | .0201      | .0114      | .18       | .0030       | .0000     | .4147            | 1.1       |

*Averages by Years.*

|   |          |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|----------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1876-77† | - | - | -   | 4.56 | -    | .0139 | .0426 | .0296 | .0130 | -   | -     | -     | -     | -   |
| - | 1887‡    | - | - | .24 | 3.63 | 1.65 | .0030 | .0486 | -     | -     | .15 | .0019 | -     | -     | -   |
| - | 1888     | - | - | .13 | 2.91 | 1.20 | .0019 | .0332 | -     | -     | .12 | .0047 | .0001 | -     | -   |
| - | 1889     | - | - | .11 | 2.42 | 1.07 | .0028 | .0461 | .0237 | .0224 | .10 | .0033 | .0002 | -     | -   |
| - | 1890     | - | - | .15 | 2.96 | 1.34 | .0020 | .0387 | .0210 | .0177 | .10 | .0065 | .0001 | -     | 0.9 |
| - | 1891     | - | - | .20 | 3.00 | 1.42 | .0050 | .0425 | .0228 | .0197 | .09 | .0050 | .0001 | -     | 0.8 |
| - | 1892§    | - | - | .28 | 3.41 | 1.41 | .0006 | .0277 | .0189 | .0088 | .13 | .0049 | .0001 | -     | 1.0 |
| - | 1893     | - | - | .47 | 4.11 | 2.03 | .0011 | .0375 | .0259 | .0116 | .14 | .0019 | .0001 | .5779 | 1.2 |
| - | 1894     | - | - | .37 | 3.39 | 1.47 | .0009 | .0221 | .0165 | .0066 | .16 | .0018 | .0000 | .4185 | 1.1 |
| - | 1895     | - | - | .29 | 3.35 | 1.55 | .0028 | .0315 | .0201 | .0114 | .18 | .0030 | .0000 | .4147 | 1.1 |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

† These analyses were made by Prof. William R. Nichols, for the city of Springfield, from samples collected about once a week, between July 1, 1876, and Sept. 30, 1877.

‡ June to December.

§ January to September.

|| May to December.

**NOTE** to analyses of 1895: Odor, vegetable and mouldy or unpleasant, becoming stronger during the latter half of the year. — The samples were collected from the reservoir 2 or 3 feet beneath the surface.

For monthly record of height of water, see page 306.

[illegible]

SPRINGFIELD.

*Microscopical Examination of Water from Ludlow Reservoir — Concluded.*

[Number of organisms per cubic centimeter.]

|                         | 1895. |       |      |      |       |       |       |       |       |       |      |      |
|-------------------------|-------|-------|------|------|-------|-------|-------|-------|-------|-------|------|------|
|                         | July. | July. | Aug. | Aug. | Sept. | Sept. | Oct.  | Oct.  | Nov.  | Nov.  | Dec. | Dec. |
| <b>ANIMALS — Con.</b>   |       |       |      |      |       |       |       |       |       |       |      |      |
| Amoebae, . . . .        | 0     | 1     | 0    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 2    | 6    |
| Aurea, . . . .          | 0     | 1     | 0    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 1    | 0    |
| Rotatorian ova, . . . . | 0     | 0     | 0    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 1    | 3    |
| Rotifer, . . . .        | 0     | 0     | 0    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0    | 3    |
| Infusorians, . . . .    | .20   | .06   | .14  | 0    | .02   | 0     | 0     | .04   | 0     | 0     | 0    | 0    |
| Cyclops, . . . .        | 0     | .06   | .08  | 0    | 0     | 0     | 0     | .04   | 0     | 0     | 0    | 0    |
| Daphnia, . . . .        | .20   | 0     | .06  | 0    | .02   | 0     | 0     | 0     | 0     | 0     | 0    | 0    |
| <b>Plantae —</b>        |       |       |      |      |       |       |       |       |       |       |      |      |
| Cellulose, . . . .      | 0     | 0     | .10  | .28  | 0     | 0     | 0     | 0     | 0     | 0     | 0    | 120  |
| Acarina, . . . .        | 0     | 0     | .10  | .06  | 0     | 0     | 0     | 0     | 0     | 0     | 0    | 0    |
| Zooglaea, . . . .       | 0     | 0     | 0    | .28  | 0     | 0     | 0     | 0     | 0     | 0     | 0    | 120  |
| TOTAL, . . . .          | 3,256 | 4,941 | 682  | 631  | 2,242 | 1,602 | 5,000 | 4,700 | 3,150 | 4,000 | 380  | 215  |

*Chemical Examination of Water from a Faucet in Springfield supplied from the Springfield Water Works.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.<br>Jan. 10    | Slight.     | V. slight. | .60    | 3.85                    | 1.40              | .0016    | .0126       | .0126      | .0000      | .22       | .0080       | .0002     | .4992            | 1.6       |

Dor, faintly vegetable, becoming stronger on heating. — The sample was collected from a faucet in the office of the water works.

*Microscopical Examination.*

Matomaceae, Astertonella, 1. Infusoria, Peridinium, 1. Total, 2.

**SPRINGFIELD.**

*Table showing Heights of Water in Ludlow Reservoir on the First of Each Month in 1895.*

NOTE.—Height of rollway, 28.1 feet above bottom of reservoir.

| DATE.      |   | Height of Water above Bottom of Reservoir. | DATE.      |   | Height of Water above Bottom of Reservoir. |
|------------|---|--------------------------------------------|------------|---|--------------------------------------------|
| 1895.      |   | Feet.                                      | 1895.      |   | Feet.                                      |
| Jan. 1, .  | . | 15.30                                      | July 1, .  | . | 17.66                                      |
| Feb. 1, .  | . | 17.16                                      | Aug. 1, .  | . | 17.30                                      |
| March 1, . | . | 16.73                                      | Sept. 1, . | . | 16.20                                      |
| April 1, . | . | 18.75                                      | Oct. 1, .  | . | 15.25                                      |
| May 1, .   | . | 18.40                                      | Nov. 1, .  | . | 13.75                                      |
| June 1, .  | . | 18.36                                      | Dec. 1, .  | . | 13.06                                      |

## WATER SUPPLY OF STOCKBRIDGE. — STOCKBRIDGE WATER COMPANY.

*Chemical Examination of Water from Lake Averic, Stockbridge.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.     |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-----------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.      | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                 |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 14292   | 1895. May 13        | Slight.         | Cons.     | .15    | 5.80                    | 1.50              | .0010    | .0152       | .0144      | .0008      | .07       | .0030       | .0000     | .2370            | 4.0       |
| 15537   | Nov. 12             | Decided, green. | Slight.   | .12    | 6.10                    | 1.20              | .0004    | .0274       | .0192      | .0082      | .06       | .0070       | .0000     | .2746            | 4.9       |

Odor of the first sample, none; of the second, decidedly oily. — The samples were collected from the reservoir just beneath the surface.

### Microscopical Examination.

No. 14292. Diatomaceæ, *Asterionella*, 11; *Cyclotella*, 1; *Fragilaria*, 1; *Nauticula*, 2; *Synedra*, 24. Algae, *Scenedesmus*, 1. Fungi, *Crenothrix*, 3. Vermes, *Rotifer*, 1. Miscellaneous, *Acarina*, .01; *Zoöglæa*, 3. Total, 47.

No. 15537. Diatomaceæ, *Asterionella*, 7. Algae, *Fotroz*, 20. Fungi, *Crenothrix*, 1. Infusoria, *Peridinium*, 2; *Trachelomonas*, 1. Vermes, *Rotifer*, 1. Total, 32.

## WATER SUPPLY OF STONEHAM.

(See Wakefield.)

## STOUGHTON.

## WATER SUPPLY OF STOUGHTON.

The advice of the State Board of Health to the town of Stoughton relative to an additional supply of water for the town may be found in pages 47-50 of this volume. Analyses of samples of water collected during the investigation for an additional supply may be found on page 316 of the annual report for 1894.

*Chemical Examination of Water from the Stoughton Water Works.*

[Parts per 100,000.]

| ANALYST. | Date of Collection.         | APPEARANCE.    |                     |            | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA.       |                |                |                 | Chlorine.  | NITROGEN<br>AS |                | Oxygen Consumed. |            | Hardness. |
|----------|-----------------------------|----------------|---------------------|------------|---------------------------------|----------------------|----------------|----------------|----------------|-----------------|------------|----------------|----------------|------------------|------------|-----------|
|          |                             | Turbidity.     | Sediment.           | Color.     | Total.                          | Loss on<br>Ignition. | Free.          | Albuminoid.    |                |                 |            | Nitrates.      | Nitrites.      | Oxygen Consumed. | Hardness.  |           |
|          |                             |                |                     |            |                                 |                      |                | Total.         | Dissolved.     | Sus-<br>pended. |            |                |                |                  |            |           |
|          |                             |                |                     |            |                                 |                      |                |                |                |                 |            |                |                |                  |            |           |
| 25<br>34 | 1895.<br>Jan. 27<br>Mar. 24 | None.<br>None. | None.<br>V. slight. | .12<br>.12 | 3.40<br>3.25                    | 0.80<br>0.95         | .0002<br>.0002 | .0056<br>.0048 | .0044<br>.0034 | .0012<br>.0014  | .35<br>.35 | .0200<br>.0030 | .0000<br>.0000 | .1722<br>.1655   | 0.8<br>0.9 |           |

Odor, none. A distinctly vegetable odor was developed in the second sample, on heating. — The first sample was collected from a faucet in the town and the second from a faucet at the pumping station.

*Microscopical Examination.*

No. 13725. No organisms.

No. 14034. Diatomaceæ, *Diatoma*, 1; *Fragilaria*, 1; *Meridion*, 1; *Navicula*, 1; *Synedra*, 2; *Zoëspores*, 1. Fungi, *Oreothrix*, 3; *Molds*, 1. Total, 11.

## WATER SUPPLY OF SWAMPSCOTT AND NAHANT. — MARBLEHEAD WATER COMPANY.

In 1895 the sources of supply of this company were increased by the construction of temporary works for drawing water from a system of ten tubular wells located a short distance east of the Swampscott station, in the angle formed by the main line of the Eastern Division of the Boston & Maine Railroad and the Marblehead branch. The wells are in the vicinity of a small tributary of Stacy's brook, which flows through this territory, and are in a line parallel to the main line of the Eastern Division. They are 12 feet apart in the line, and range in depth from 30 to 47 feet. These wells are from 800 to 1,000 feet distant from the wells of the Marblehead Water Company in Paradise Road. Between Aug. 6 and Nov. 2, 1895, about 14,500,000 gallons are said to have been drawn from this source for the supply of the towns.



## SWAMPSCOTT AND NAHANT.

*Chemical Examination of Water from the Wells of the Marblehead Water Company, Swampscott.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |                   |        | Residue on Evaporation. | AMMONIA. |              | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------------|-------------------|--------|-------------------------|----------|--------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.        | Sediment.         | Color. |                         | Free.    | Alb.-minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 13614   | 1895.<br>Jan. 7     | None.             | V. slight.        | .03    | 12.60                   | .0004    | .0030        | 1.57      | .0400       | .0000     | .0429            | 6.6       | .0030 |
| 13775   | Feb. 6              | Decided, milky.   | None.             | .20    | 9.80                    | .0010    | .0054        | 1.27      | .0320       | .0000     | .1288            | 4.2       | .0020 |
| 13931   | Mar. 5              | Distinct, clayey. | V. slight.        | .10    | 24.80                   | .0004    | .0056        | 5.55      | .1500       | .0000     | .1401            | 10.5      | .0110 |
| 14086   | Apr. 2              | V. slight, milky. | V. slight, white. | .05    | 12.50                   | .0000    | .0028        | 1.34      | .0100       | .0000     | .0731            | 6.1       | .0030 |
| 14251   | May 6               | None.             | V. slight.        | .05    | 12.70                   | .0000    | .0020        | 1.46      | .0600       | .0000     | .0670            | 5.9       | .0020 |
| 14417   | June 4              | V. slight.        | V. slight.        | .10    | 11.50                   | .0002    | .0050        | 1.28      | .0420       | .0000     | .1482            | 5.1       | .0100 |
| 14605   | July 9              | None.             | V. slight.        | .00    | 70.90                   | .0000    | .0008        | 19.30     | .1640       | .0000     | .0276            | 14.4      | .0050 |
| 14799   | Aug. 6              | None.             | None.             | .00    | 43.90                   | .0000    | .0012        | 9.60      | .2500       | .0000     | .0624            | 16.4      | .0050 |
| 14989   | Sept. 4             | None.             | None.             | .02    | 81.50                   | .0000    | .0008        | 24.55     | .3300       | .0000     | .0524            | 15.2      | .0230 |
| 15308   | Oct. 2              | None.             | None.             | .00    | 14.90                   | .0000    | .0004        | 2.00      | .1100       | .0000     | .0000            | 7.3       | .0010 |
| 15488   | Nov. 6              | Slight, rusty.    | Slight, rusty.    | .18    | 47.70                   | .0002    | .0070        | 13.60     | .1400       | .0000     | .2200            | 16.0      | .0130 |
| 15685   | Dec. 3              | Slight, milky.    | V. slight.        | .23    | 11.30                   | .0000    | .0054        | 1.37      | .0500       | .0000     | .2028            | 4.7       | .0080 |
| Av.     | .....               | .....             | .....             | .08    | 29.51                   | .0002    | .0033        | 6.91      | .1148       | .0000     | .0971            | 9.4       | .0072 |

*Averages by Years.*

|   |       |   |   |     |       |       |       |       |       |       |       |      |       |
|---|-------|---|---|-----|-------|-------|-------|-------|-------|-------|-------|------|-------|
| - | 1887* | - | - | .03 | 23.88 | .0032 | .0028 | 2.94  | .5302 | -     | -     | -    | -     |
| - | 1888  | - | - | .00 | 25.16 | .0007 | .0035 | 3.26  | .4477 | .0003 | -     | -    | -     |
| - | 1889† | - | - | .00 | 26.20 | .0006 | .0033 | 3.80  | .4390 | .0002 | -     | -    | -     |
| - | 1890‡ | - | - | .00 | 44.00 | .0006 | .0010 | 8.30  | .6250 | .0001 | -     | 21.2 | -     |
| - | 1891  | - | - | .00 | 38.64 | .0018 | .0010 | 7.73  | .9909 | .0002 | -     | 18.0 | -     |
| - | 1892  | - | - | .00 | 54.94 | .0000 | .0010 | 14.53 | .7437 | .0000 | -     | 22.0 | -     |
| - | 1893  | - | - | .01 | 46.42 | .0000 | .0022 | 12.12 | .4263 | .0000 | .0747 | 14.7 | .0061 |
| - | 1894  | - | - | .04 | 37.84 | .0002 | .0018 | 10.52 | .2983 | .0000 | .0506 | 15.8 | .0066 |
| - | 1895  | - | - | .08 | 29.51 | .0002 | .0033 | 6.91  | .1148 | .0000 | .0971 | 9.4  | .0072 |

\* June to December.

† January to May.

‡ October.

NOTE to analyses of 1895: Odor, none, except in June, when it was faintly vegetable and musty. — The samples were collected from a faucet at the pumping station.

*Microscopical Examination.*

The average number of organisms per cubic centimeter found in these samples was 53, consisting chiefly of *Crenothrix*.

SWAMPSCOTT AND NAHANT.

*Chemical Examination of Water from Tubular Wells a Short Distance East of the Swampscott Railroad Station in Swampscott.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE.       |           |        | Residue on Evaporation. | AMMONIA. |             |  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------------------|-------------------|-----------|--------|-------------------------|----------|-------------|--|-----------|-------------|-----------|------------------|-----------|-------|
|                     | Turbidity.        | Sediment. | Color. |                         | Free.    | Albuminoid. |  |           | Nitrates.   | Nitrites. |                  |           |       |
| 1895.<br>Aug. 21    | V. slight, milky. | None.     | .01    | 12.50                   | .0000    | .0000       |  | 1.48      | .0200       | .0060     | .0156            | 5.7       | .0100 |
| 81 Sept. 16         | None.             | None.     | .03    | 12.50                   | .0000    | .0010       |  | 1.42      | .0150       | .0002     | .0094            | 6.1       | .0060 |

Odor, none. — The samples were collected from a faucet on a pump drawing water from the wells.

*Microscopical Examination.*

No organisms.

WATER SUPPLY OF TAUNTON.

*Chemical Examination of Water from Assawompsett Pond, Lakeville.*

[Parts per 100,000.]

| DATE.   | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
|         | 1893.               |             |            |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 11      | Jan. 24             | V. slight.  | V. slight. | .45    | 3.45                            | 1.85                 | .0004    | .0165       | .0158      | .0010           | .53       | .0030          | .0000     | .5451            | 0.8       |
| 88      | Feb. 25             | V. slight.  | Slight.    | .70    | 4.15                            | 1.95                 | .0010    | .0202       | .0188      | .0014           | .55       | .0000          | .0000     | .7426            | 0.9       |
| 38      | Mar. 25             | Slight.     | Cons.      | .53    | 3.45                            | 1.50                 | .0002    | .0174       | .0146      | .0028           | .47       | .0000          | .0000     | .5505            | 0.9       |
| 98      | Apr. 22             | Slight.     | Cons.      | .53    | 3.50                            | 1.80                 | .0000    | .0160       | .0136      | .0024           | .49       | .0000          | .0000     | .6675            | 0.0       |
| 75      | May 27              | Slight.     | Cons.      | .48    | 3.50                            | 2.25                 | .0002    | .0220       | .0202      | .0018           | .53       | .0000          | .0000     | .6966            | 0.5       |
| 42      | June 25             | Distinct.   | Cons.      | .43    | 3.70                            | 1.85                 | .0002    | .0190       | .0166      | .0024           | .51       | .0000          | .0000     | .5298            | 0.5       |
| 30      | July 29             | V. slight.  | Cons.      | .30    | 3.10                            | 0.90                 | .0014    | .0220       | .0174      | .0046           | .56       | .0050          | .0000     | .5082            | 0.9       |
| 11      | Aug. 26             | Slight.     | Slight.    | .20    | 2.90                            | 1.10                 | .0014    | .0178       | .0142      | .0036           | .58       | .0030          | .0000     | .4134            | 0.4       |
| 39      | Sept. 23            | None.       | V. slight. | .08    | 3.20                            | 1.35                 | .0002    | .0188       | .0158      | .0030           | .56       | .0020          | .0000     | .3900            | 0.9       |
| 39      | Oct. 28             | Slight.     | Slight.    | .15    | 2.90                            | 1.35                 | .0004    | .0174       | .0138      | .0036           | .54       | .0030          | .0000     | .3526            | 0.5       |
| 10      | Nov. 26             | Slight.     | Cons.      | .18    | 2.80                            | 1.05                 | .0002    | .0174       | .0136      | .0038           | .51       | .0000          | .0000     | .3098            | 0.5       |
| 98      | Dec. 23             | Slight.     | Slight.    | .25    | 3.40                            | 1.50                 | .0010    | .0166       | .0136      | .0030           | .50       | .0000          | .0000     | .4327            | 0.8       |
| Average | .....               | .....       | .....      | .36    | 3.34                            | 1.54                 | .0003    | .0185       | .0157      | .0028           | .53       | .0013          | .0000     | .5032            | 0.7       |

*Averages by Years.*

| Year  | Turbidity | Sediment | Color | Total | Loss on Ignition | Free  | Albuminoid | Chlorine | Nitrates | Nitrites | Oxygen Consumed | Hardness |
|-------|-----------|----------|-------|-------|------------------|-------|------------|----------|----------|----------|-----------------|----------|
| 1887* | -         | -        | .45   | 3.63  | 1.57             | .0005 | .0180      | -        | .48      | .0015    | -               | -        |
| 1888† | -         | -        | .30   | 4.20  | 1.35             | .0001 | .0238      | -        | .45      | .0030    | .0001           | -        |
| 1891‡ | -         | -        | .03   | 2.80  | 1.02             | .0000 | .0157      | .0110    | .0047    | .46      | .0025           | .0000    |
| 1894  | -         | -        | .33   | 3.22  | 1.26             | .0003 | .0157      | .0132    | .0025    | .51      | .0021           | .0000    |
| 1896  | -         | -        | .36   | 3.34  | 1.54             | .0005 | .0185      | .0157    | .0028    | .53      | .0013           | .0000    |

\* June and September.

† January and May.

‡ December, two samples.

NOTE to analyses of 1895: Odor, generally faintly vegetable; sometimes none. In May the odor was distinctly oily on heating. — The samples were collected from the pond at the intake of the Taunton Water Works.

## TAUNTON.

*Microscopical Examination of Water from Assawompsett Pond, Lakeville.*

[Number of organisms per cubic centimeter.]

|                                      | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|--------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                      | Jan.  | Feb.  | Mar.  | Apr.  | May   | June  | July  | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . . .        | 26    | 27    | 27    | 23    | 29    | 26    | 31    | 28    | 26    | 30    | 27    | 26    |
| Number of sample, . . . . .          | 13711 | 13888 | 14038 | 14196 | 14375 | 14542 | 14730 | 14911 | 15239 | 15439 | 15610 | 15798 |
| <b>PLANTS.</b>                       |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>Diatomaceæ,</b> . . . . .         | 101   | 52    | 166   | 229   | -     | 71    | 62    | 21    | 17    | 119   | 50    | 33    |
| Asterionella, . . . . .              | 99    | 41    | 88    | 95    | -     | 46    | 13    | 0     | 8     | 64    | 2     | 0     |
| Cyclotella, . . . . .                | 0     | 0     | 1     | 2     | -     | 17    | 3     | 0     | 0     | 0     | 3     | 1     |
| Diatoma, . . . . .                   | 0     | 0     | 1     | 0     | -     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Melosira, . . . . .                  | 0     | 0     | 9     | 72    | -     | 4     | 36    | 18    | 9     | 0     | 54    | 0     |
| Navicula, . . . . .                  | 0     | 1     | 3     | 1     | -     | 0     | 5     | 0     | 0     | 3     | 6     | 0     |
| Synedra, . . . . .                   | 1     | 10    | 52    | 52    | -     | 4     | 2     | 2     | 0     | 44    | 1     | 28    |
| Tabellaria, . . . . .                | 1     | 0     | 12    | 7     | -     | 0     | 3     | 1     | 0     | 2     | 4     | 4     |
| <b>Cyanophyceæ,</b> . . . . .        | 0     | 0     | 0     | 0     | -     | 3     | 0     | 3     | 10    | 0     | 0     | 0     |
| Chroococcus, . . . . .               | 0     | 0     | 0     | 0     | -     | 0     | 0     | 0     | 10    | 0     | 0     | 0     |
| Microcystis, . . . . .               | 0     | 0     | 0     | 0     | -     | 3     | 0     | 3     | 0     | 0     | 0     | 0     |
| <b>Algæ,</b> . . . . .               | 0     | 0     | 15    | 6     | -     | 268   | 30    | 79    | 0     | 26    | 0     | 1     |
| Chlorococcus, . . . . .              | 0     | 0     | 0     | 6     | -     | 0     | 0     | 0     | 0     | 3     | 0     | 0     |
| Hyalotheca, . . . . .                | 0     | 0     | 10    | 0     | -     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Protooccus, . . . . .                | 0     | 0     | 5     | 0     | -     | 268   | 30    | 79    | 0     | 9     | 0     | 0     |
| Raphidium, . . . . .                 | 0     | 0     | 0     | 0     | -     | 0     | 0     | 0     | 0     | 14    | 0     | 1     |
| <b>Fungi,</b> . . . . .              | 1     | 0     | 0     | 2     | -     | 28    | 4     | 0     | 3     | 4     | 2     | 0     |
| Crenothrix, . . . . .                | 1     | 0     | 0     | 2     | -     | 28    | 4     | 0     | 0     | 0     | 2     | 0     |
| Molds, . . . . .                     | 0     | 0     | 0     | 0     | -     | 0     | 0     | 0     | 3     | 4     | 0     | 0     |
| <b>ANIMALS.</b>                      |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>Infusoria,</b> . . . . .          | 46    | 188   | 120   | 94    | -     | 2     | 5     | 16    | 17    | 5     | 0     | 1     |
| Dinobryon, . . . . .                 | 32    | 94    | 44    | 0     | -     | 0     | 0     | 16    | 17    | 0     | 0     | 11    |
| Dinobryon cases, . . . . .           | 11    | 92    | 72    | 92    | -     | 0     | 2     | 0     | 0     | 0     | 0     | 0     |
| Peridinium, . . . . .                | 3     | 2     | 4     | 2     | -     | 1     | 3     | 0     | 0     | 4     | 0     | 0     |
| Trachelomonas, . . . . .             | 0     | 0     | 0     | 0     | -     | 1     | 0     | 0     | 0     | 1     | 0     | 0     |
| <b>Vermes, Anurea,</b> . . . . .     | 0     | 0     | 0     | 0     | -     | 1     | 1     | 0     | 2     | 1     | 0     | 0     |
| <b>Crustacea, Cyclops,</b> . . . . . | 0     | 0     | 0     | .02   | -     | 0     | 0     | .04   | 0     | 0     | 0     | 0     |
| <b>Miscellaneous,</b> . . . . .      | 0     | 0     | 0     | 2     | -     | 0     | .02   | 2     | 24    | 100   | 0     | 0     |
| Acarina, . . . . .                   | 0     | 0     | 0     | 0     | -     | 0     | .02   | 0     | .04   | 0     | 0     | 0     |
| Zoöglæa, . . . . .                   | 0     | 0     | 0     | 2     | -     | 0     | 0     | 2     | 24    | 100   | 0     | 0     |
| <b>TOTAL,</b> . . . . .              | 148   | 240   | 301   | 333   | -     | 373   | 102   | 121   | 73    | 255   | 52    | 45    |

TAUNTON.

*Chemical Examination of Water from Elder's Pond, Lakeville.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
|         | 1895.               |             |            |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 13712   | Jan. 24             | V. slight.  | V. slight. | .03    | 2.65                    | 1.20              | .0002    | .0150       | .0134      | .0016      | .44       | .0030       | .0000     | .2014            | 0.5       |
| 13889   | Feb. 25             | V. slight.  | Slight.    | .05    | 2.75                    | 0.90              | .0000    | .0152       | .0144      | .0008      | .49       | .0000       | .0000     | .2291            | 0.6       |
| 14037   | Mar. 25             | V. slight.  | Slight.    | .07    | 2.80                    | 1.30              | .0004    | .0128       | .0116      | .0012      | .44       | .0000       | .0000     | .2387            | 0.6       |
| 14197   | Apr. 22             | Slight.     | Cons.      | .03    | 2.15                    | 0.85              | .0000    | .0134       | .0120      | .0014      | .46       | .0000       | .0000     | .2093            | 0.5       |
| 14376   | May 27              | V. slight.  | Cons.      | .05    | 2.75                    | 1.15              | .0000    | .0232       | .0212      | .0020      | .46       | .0000       | .0000     | .2698            | 0.5       |
| 14541   | June 25             | Slight.     | Slight.    | .08    | 3.05                    | 1.25              | .0000    | .0156       | .0136      | .0020      | .46       | .0000       | .0000     | .1925            | 0.5       |
| 14729   | July 29             | V. slight.  | Slight.    | .05    | 2.60                    | 0.60              | .0000    | .0170       | .0148      | .0022      | .49       | .0070       | .0000     | .2618            | 0.8       |
| 14912   | Aug. 26             | Slight.     | Slight.    | .05    | 2.80                    | 0.85              | .0000    | .0172       | .0132      | .0040      | .46       | .0030       | .0000     | .2028            | 0.3       |
| 15238   | Sept. 23            | None.       | Slight.    | .08    | 2.55                    | 1.00              | .0002    | .0166       | .0148      | .0018      | .48       | .0060       | .0000     | .2379            | 0.2       |
| 15440   | Oct. 28             | V. slight.  | V. slight. | .08    | 2.80                    | 0.95              | .0000    | .0162       | .0150      | .0012      | .48       | .0030       | .0000     | .2262            | 0.5       |
| 15611   | Nov. 26             | V. slight.  | Slight.    | .04    | 2.85                    | 0.65              | .0004    | .0148       | .0134      | .0014      | .43       | .0000       | .0000     | .1794            | 0.3       |
| 15797   | Dec. 23             | Slight.     | V. slight. | .03    | 2.60                    | 1.05              | .0002    | .0166       | .0144      | .0022      | .49       | .0000       | .0000     | .2502            | 0.3       |
| Av.     | .....               | .....       | .....      | .05    | 2.57                    | 0.98              | .0001    | .0161       | .0143      | .0018      | .46       | .0018       | .0000     | .2249            | 0.5       |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | .00 | 2.50 | 0.58 | .0004 | .0130 | -     | -     | .41 | .0030 | -     | -     | -   |
| - | 1888† | - | - | .05 | 2.00 | 0.45 | .0000 | .0138 | -     | -     | .35 | .0000 | .0000 | -     | -   |
| - | 1891‡ | - | - | .00 | 2.03 | 0.90 | .0000 | .0143 | .0120 | .0023 | .40 | .0010 | .0001 | -     | 0.3 |
| - | 1894  | - | - | .04 | 2.32 | 0.94 | .0004 | .0135 | .0120 | .0015 | .42 | .0015 | .0000 | .1668 | 0.4 |
| - | 1895  | - | - | .05 | 2.57 | 0.98 | .0001 | .0161 | .0143 | .0018 | .46 | .0018 | .0000 | .2249 | 0.5 |

\* September.

† May.

‡ December, two samples.

NOTE to analyses of 1895: Odor, generally faintly vegetable, sometimes none. The odor generally became stronger on heating. — The samples were collected from the pond near the gate-house of the Taunton Water Works.

## TAUNTON.

*Microscopical Examination of Water from Elder's Pond, Lakeville.*

[Number of organisms per cubic centimeter.]

|                                      | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|--------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                      | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .            | 26    | 27    | 27    | 23    | 29    | 26    | 31    | 29    | 25    | 31    | 27    | 26    |
| Number of sample, . . .              | 13712 | 13889 | 14037 | 14197 | 14376 | 14541 | 14729 | 14912 | 15238 | 15440 | 15611 | 15797 |
| <b>PLANTS.</b>                       |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>Diatomaceæ, . . .</b>             | 33    | 1     | 11    | 17    | 5     | 21    | 44    | 274   | 13    | 20    | 29    | 40    |
| Asterionella, . . .                  | 33    | 1     | 3     | 11    | 0     | 0     | 15    | 252   | 12    | 15    | 0     | 16    |
| Cyclotella, . . .                    | pr.   | 0     | 0     | 0     | 0     | 3     | 9     | 0     | 0     | 3     | 24    | 17    |
| Diatoma, . . .                       | 0     | 0     | 0     | 0     | 2     | 2     | 0     | 2     | 0     | 0     | 0     | 0     |
| Navicula, . . .                      | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 0     | 1     | 1     | 2     | 2     |
| Synedra, . . .                       | pr.   | 0     | 3     | 5     | 3     | 3     | 7     | 20    | 0     | 1     | 3     | 5     |
| Tabellaria, . . .                    | 0     | 0     | 5     | 1     | 0     | 13    | 9     | 0     | 0     | 0     | 0     | 0     |
| <b>Cyanophyceæ, . . .</b>            | pr.   | 0     | 0     | 0     | 20    | 136   | 75    | 110   | 115   | 48    | 6     | 28    |
| Anabaena, . . .                      | 0     | 0     | 0     | 0     | 20    | 0     | 2     | 0     | 60    | 0     | 0     | 0     |
| Merismopedia, . . .                  | 0     | 0     | 0     | 0     | 0     | 0     | 5     | 5     | 0     | 0     | 0     | 0     |
| Microcystis, . . .                   | pr.   | 0     | 0     | 0     | 0     | 136   | 68    | 84    | 52    | 48    | 6     | 28    |
| Oscillaria, . . .                    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 18    | 2     | 0     | 0     | 0     |
| <b>Algæ, . . .</b>                   | 10    | 0     | 2     | 0     | 20    | 7     | 31    | 29    | 10    | 0     | 1     | 12    |
| Glaucocapsa, . . .                   | 0     | 0     | 0     | 0     | 20    | 0     | 0     | 7     | 0     | 0     | 1     | 0     |
| Protococcus, . . .                   | 6     | 0     | 0     | 0     | 0     | 7     | 23    | 18    | 8     | 0     | 0     | 0     |
| Raphidium, . . .                     | 4     | 0     | 2     | 0     | 0     | 0     | 8     | 4     | 2     | 0     | 0     | 12    |
| <b>ANIMALS.</b>                      |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>Infusoria, . . .</b>              | 1     | 26    | 33    | 6     | 4     | 1     | 9     | 49    | 4     | 0     | 9     | 3     |
| Dinobryon, . . .                     | 0     | 19    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 8     | 0     |
| Dinobryon caeca, . . .               | pr.   | 5     | 32    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 3     |
| Encysted infusorian, . . .           | 0     | 0     | 0     | 5     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Peridinium, . . .                    | 1     | 2     | 1     | 1     | 0     | 0     | 7     | 48    | 3     | 0     | 1     | 0     |
| Phacus, . . .                        | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 1     | 0     | 0     | 0     |
| Trachelomonas, . . .                 | 0     | 0     | 0     | 0     | 0     | 1     | 2     | 0     | 0     | 0     | 0     | 0     |
| Vorticella, . . .                    | 0     | 0     | 0     | 0     | 4     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| <b>Vermes, Anurea, . . .</b>         | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 1     |
| <b>Miscellaneous, Zoöglæa, . . .</b> | 42    | 9     | 36    | 0     | 40    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| <b>TOTAL, . . .</b>                  | 86    | 36    | 82    | 23    | 89    | 165   | 159   | 462   | 143   | 68    | 45    | 84    |

## TAUNTON.

*nical Examination of Water from the Filter-basin of the Taunton Water Works.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------------------|-------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|                     | Turbidity.  | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|                     |             |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| <b>1895.</b>        |             |                   |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| Jan. 24             | V slight.   | Slight.           | .05    | 4.15                            | 1.00                 | .0000    | .0114       | .0070      | .0044           | .56       | .0400          | .0000     | .0948            | 1.4       |
| Feb. 25             | Slight.     | Cons.             | .02    | 4.40                            | 1.20                 | .0000    | .0132       | .0080      | .0052           | .40       | .0350          | .0001     | .0727            | 1.6       |
| Mar. 25             | Slight.     | Slight.           | .05    | 3.95                            | 1.35                 | .0002    | .0114       | .0058      | .0056           | .56       | .0380          | .0002     | .0847            | 1.4       |
| Apr. 22             | Slight.     | Cons.             | .10    | 3.85                            | 1.25                 | .0000    | .0124       | .0074      | .0050           | .56       | .0150          | .0001     | .2354            | 1.4       |
| May 27              | Distinct.   | Cons.             | .10    | 4.75                            | 1.55                 | .0000    | .0208       | .0108      | .0100           | .61       | .0220          | .0005     | .2090            | 1.6       |
| June 25             | Distinct.   | Cons.             | .05    | 4.75                            | 1.60                 | .0006    | .0120       | .0076      | .0044           | .60       | .0300          | .0007     | .0847            | 1.3       |
| July 29             | V. slight.  | Slight.           | .18    | 3.65                            | 1.50                 | .0018    | .0112       | .0102      | .0010           | .63       | .0350          | .0005     | .2079            | 1.7       |
| Aug. 26             | Distinct.   | Slight.           | .02    | 3.75                            | 1.30                 | .0032    | .0116       | .0082      | .0034           | .60       | .0200          | .0005     | .0702            | 1.1       |
| Sept. 23            | Slight.     | V. slight.        | .08    | 4.10                            | 1.35                 | .0050    | .0204       | .0114      | .0090           | .56       | .0180          | .0005     | .1685            | 1.4       |
| Oct. 28             | Distinct.   | Slight.           | .12    | 4.05                            | 1.20                 | .0004    | .0212       | .0122      | .0090           | .57       | .0150          | .0002     | .1888            | 1.1       |
| Nov. 25             | Slight.     | Slight,<br>green. | .07    | 3.85                            | 1.05                 | .0004    | .0122       | .0076      | .0046           | .58       | .0150          | .0001     | .1482            | 1.4       |
| Dec. 23             | Slight.     | Slight,<br>gray.  | .03    | 3.85                            | 1.10                 | .0014    | .0110       | .0066      | .0044           | .59       | .0220          | .0001     | .2502            | 1.1       |
| .....               | .....       | .....             | .07    | 4.08                            | 1.28                 | .0011    | .0141       | .0086      | .0055           | .57       | .0254          | .0003     | .1513            | 1.4       |

## Averages by Years.

|       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| 1887* | - | - | .29 | 5.66 | -    | .0017 | .0092 | -     | -     | .60 | .0167 | -     | -     | -   |
| 1888  | - | - | .47 | 5.40 | -    | .0010 | .0120 | -     | -     | .53 | .0150 | .0001 | -     | -   |
| 1889  | - | - | .29 | 5.12 | -    | .0012 | .0073 | -     | -     | .57 | .0185 | .0001 | -     | -   |
| 1890  | - | - | .33 | 5.91 | -    | .0012 | .0087 | -     | -     | .57 | .0227 | .0001 | -     | 1.9 |
| 1891  | - | - | .35 | 5.25 | 3.76 | .0014 | .0073 | -     | -     | .55 | .0212 | .0000 | -     | 1.7 |
| 1892  | - | - | .60 | 5.53 | 3.88 | .0005 | .0124 | -     | -     | .58 | .0147 | .0001 | -     | 1.6 |
| 1893  | - | - | .82 | 5.41 | 1.82 | .0026 | .0149 | -     | -     | .57 | .0114 | .0001 | .6763 | 1.4 |
| 1894  | - | - | .26 | 4.36 | 1.16 | .0008 | .0132 | .0095 | .0037 | .55 | .0175 | .0001 | .2871 | 1.2 |
| 1895  | - | - | .07 | 4.08 | 1.28 | .0011 | .0141 | .0086 | .0055 | .57 | .0254 | .0003 | .1513 | 1.4 |

\* June to December.

For notes to analyses of 1895: Odor, generally vegetable; in August and September, decidedly disagreeable. — The samples were collected from the filter-basin.

## TAUNTON.

*Microscopical Examination of Water from the Filter-basin of the Taunton Water Works.*

[Number of organisms per cubic centimeter.]

|                            | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                            | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .  | 26    | 28    | 28    | 23    | 29    | 26    | 31    | 29    | 25    | 30    | 27    | 26    |
| Number of sample, . . .    | 13714 | 13887 | 14040 | 14109 | 14378 | 14544 | 14732 | 14914 | 15237 | 15438 | 15613 | 15796 |
| <b>PLANTS.</b>             |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .          | 206   | 652   | 741   | 1,348 | 6,672 | 580   | 21    | 318   | 7     | 76    | 51    | 138   |
| Asterionella, . . .        | 204   | 628   | 580   | 660   | 72    | 0     | 1     | 0     | 2     | 30    | 31    | 110   |
| Cyclotella, . . .          | 0     | 0     | 0     | 0     | 0     | 216   | 3     | 0     | 5     | 0     | 0     | 0     |
| Diatoma, . . .             | 1     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 8     | 13    | 0     |
| Fragilaria, . . .          | 0     | 0     | 20    | 0     | 0     | 0     | 12    | 62    | 0     | 0     | 0     | 0     |
| Navicula, . . .            | 1     | 1     | 1     | 0     | 0     | 0     | 1     | 0     | 0     | 2     | 0     | pr.   |
| Synedra, . . .             | 0     | 22    | 140   | 1,288 | 6,600 | 364   | 4     | 256   | 0     | 36    | 7     | 28    |
| Cyanophyceæ, Oscillaria, . | 0     | pr.   | 1     | 1     | 0     | 0     | 0     | 11    | 0     | 0     | 0     | 0     |
| Algæ, . . .                | 0     | 152   | 125   | 0     | 28    | 0     | 29    | 7     | 32    | 68    | 80    | 27    |
| Chlorococcus, . . .        | 0     | 152   | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 0     |
| Celastrum, . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 24    | 0     | 0     | 0     |
| Eudorina, . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 24    | 76    | 1     |
| Pandorina, . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 26    |
| Protooccus, . . .          | 0     | 0     | 124   | 0     | 0     | 0     | 29    | 4     | 0     | 23    | 0     | 0     |
| Raphidium, . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 16    | 0     | 0     |
| Scenedesmus, . . .         | 0     | pr.   | 1     | 0     | 28    | 0     | pr.   | 2     | 6     | 0     | 0     | pr.   |
| Fungi, Crenothrix, . . .   | 0     | pr.   | 0     | 0     | 18    | 0     | 0     | 2     | 0     | 0     | 0     | 0     |
| <b>ANIMALS.</b>            |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . .           | 3     | 11    | 241   | 213   | 28    | 1     | 18    | 868   | 154   | 8     | 7     | 3     |
| Dinobryon, . . .           | 0     | 8     | 140   | 69    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon caesi, . . .     | 0     | 3     | 100   | 136   | 0     | 1     | 2     | 636   | 0     | 0     | 0     | 0     |
| Euglena, . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     |
| Monas, . . .               | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 2     |
| Peridinium, . . .          | 3     | 0     | 0     | 8     | 0     | 0     | 16    | 232   | 152   | 4     | 5     | 1     |
| Trachelomonas, . . .       | 0     | 0     | 0     | 0     | 28    | 0     | 0     | 0     | 2     | 2     | 0     | 0     |
| Vermes, . . .              | 0     | 0     | 0     | 0     | 3     | 0     | 1     | 1     | 0     | 10    | 2     | 0     |
| Aurea, . . .               | 0     | 0     | 0     | 0     | 3     | 0     | 1     | 1     | 0     | 6     | 2     | 0     |
| Rotatorian ova, . . .      | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 0     | 0     |
| Miscellaneous, Zoöglæa, .  | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 18    | 40    | 0     | 0     | 0     |
| TOTAL, . . .               | 209   | 815   | 1,108 | 2,162 | 6,749 | 581   | 69    | 1,225 | 233   | 162   | 140   | 168   |

## TAUNTON.

*Chemical Examination of Water from the Taunton River, at Taunton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |          | Oxygen Consumed | Hardness. |
|---------|---------------------|-------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|----------|-----------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrate.       | Nitrite. |                 |           |
|         |                     |             |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |          |                 |           |
| 13713   | 1895.<br>Jan. 24    | Slight.     | Slight.           | 1.30   | 4.80                            | 2.35                 | .0026    | .0196       | .0186      | .0010           | .58       | .0080          | .0000    | 1.0033          | 1.3       |
| 13886   | Feb. 25             | Slight.     | Slight.           | 1.05   | 5.20                            | 2.00                 | .0046    | .0192       | .0182      | .0010           | .66       | .0120          | .0001    | 0.8255          | 1.1       |
| 14039   | Mar. 25             | Slight.     | Cons.             | 0.95   | 3.70                            | 1.35                 | .0008    | .0206       | .0194      | .0012           | .50       | .0030          | .0001    | 0.9124          | 0.9       |
| 14198   | Apr. 22             | Slight.     | Cons.             | 1.50   | 4.45                            | 2.50                 | .0010    | .0260       | .0250      | .0010           | .55       | .0030          | .0001    | 1.4615          | 0.9       |
| 14377   | May 27              | V. slight.  | Cons.             | 1.50   | 6.35                            | 3.65                 | .0022    | .0384       | .0326      | .0058           | .54       | .0100          | .0001    | 1.6340          | 1.1       |
| 14543   | June 25             | V. slight.  | Slight.           | 1.30   | 5.45                            | 2.60                 | .0016    | .0258       | .0240      | .0018           | .60       | .0050          | .0001    | 0.8778          | 0.9       |
| 14731   | July 29             | V. slight.  | Cons.             | 1.20   | 5.30                            | 1.80                 | .0024    | .0310       | .0274      | .0036           | .66       | .0100          | .0000    | 0.9350          | 1.4       |
| 14913   | Aug. 26             | V. slight.  | Slight.           | 0.85   | 5.10                            | 1.80                 | .0020    | .0234       | .0218      | .0016           | .68       | .0030          | .0001    | 0.6396          | 0.9       |
| 15236   | Sept. 23            | V. slight.  | Slight.           | 0.62   | 4.90                            | 1.95                 | .0006    | .0206       | .0194      | .0012           | .72       | .0120          | .0000    | 0.5070          | 0.9       |
| 15437   | Oct. 28             | V. slight.  | Slight.           | 1.30   | 6.55                            | 3.05                 | .0022    | .0352       | .0322      | .0030           | .76       | .0150          | .0001    | 1.3946          | 1.6       |
| 15612   | Nov. 25             | V. slight.  | Slight.           | 1.60   | 6.30                            | 3.45                 | .0010    | .0312       | .0298      | .0014           | .58       | .0050          | .0001    | 1.6302          | 1.3       |
| 15795   | Dec. 23             | Slight.     | Slight,<br>brown. | 1.10   | 4.80                            | 1.90                 | .0020    | .0212       | .0194      | .0018           | .65       | .0070          | .0002    | 1.2705          | 0.8       |
| Av.     | .....               | .....       | .....             | 1.19   | 5.24                            | 2.37                 | .0019    | .0260       | .0240      | .0020           | .62       | .0077          | .0001    | 1.0912          | 1.1       |

*Averages by Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |        |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|--------|-----|
| - | 1887* | - | - | 1.29 | 5.84 | 2.00 | .0030 | .0285 | -     | -     | .59 | .0097 | -     | -      | -   |
| - | 1888  | - | - | 1.51 | 5.25 | 2.28 | .0015 | .0294 | -     | -     | .44 | .0086 | .0001 | -      | -   |
| - | 1889  | - | - | 1.67 | 4.50 | 2.17 | .0015 | .0304 | .0270 | .0034 | .45 | .0085 | .0001 | -      | -   |
| - | 1890  | - | - | 1.31 | 5.36 | 2.27 | .0016 | .0254 | .0225 | .0029 | .48 | .0118 | .0001 | -      | 1.3 |
| - | 1891  | - | - | 1.12 | 4.77 | 1.98 | .0006 | .0220 | .0197 | .0023 | .47 | .0095 | .0001 | -      | 1.0 |
| - | 1892  | - | - | 1.08 | 5.27 | 2.20 | .0012 | .0225 | .0198 | .0027 | .54 | .0093 | .0001 | -      | 1.1 |
| - | 1893  | - | - | 1.33 | 5.33 | 2.31 | .0043 | .0246 | .0212 | .0034 | .56 | .0078 | .0002 | 1.0820 | 1.1 |
| - | 1894  | - | - | 1.28 | 5.01 | 2.15 | .0027 | .0224 | .0190 | .0034 | .60 | .0047 | .0001 | 0.9372 | 1.1 |
| - | 1895  | - | - | 1.19 | 5.24 | 2.37 | .0019 | .0260 | .0240 | .0020 | .62 | .0077 | .0001 | 1.0912 | 1.1 |

\* June to December.

NOTE to analyses of 1895: Odor, vegetable, sometimes also mouldy. — The samples were collected from the river, opposite the filter-basin of the Taunton Water Works.

*Microscopical Examination.*

The average number of organisms per cubic centimeter found in these samples was 79.



## UXBRIDGE.

## WATER SUPPLY OF UXBRIDGE.

*Chemical Examination of Water from a Well in the Yard of Capron's Mill.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                  |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |          | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------------|--------|-------------------------|----------|-------------|-----------|-------------|----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.        | Color. |                         | Free.    | Albuminoid. |           | Nitrate.    | Nitrite. |                  |           |       |
| 15374   | 1895.<br>Oct. 15    | V. slight.  | Slight, fibrous. | .04    | 6.20                    | .0138    | .0014       | .32       | .1900       | .0004    | .0507            | 2.3       | .0340 |

Odor, none; on heating, faintly unpleasant. — Water from this source was used as a supplementary supply for the town during the summer of 1896.

*Microscopical Examination.*

Miscellaneous, Zoöglan, 80.

## WATER SUPPLY OF WAKEFIELD AND STONEHAM. — WAKEFIELD WATER COMPANY.

*Chemical Examination of Water from Crystal Lake, Wakefield.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |  |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|--|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |  |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |  |
| 1895.   |                     |             |           |        |                         |                   |          |             |            |            |           |             |           |                  |           |  |
| 13974   | Mar. 13             | V. slight.  | Slight.   | .12    | 4.50                    | 1.15              | .0038    | .0146       | .0130      | .0016      | .79       | .0200       | .0000     | .2624            | 1.9       |  |
| 14472   | June 10             | V. slight.  | Slight.   | .20    | 4.45                    | 1.90              | .0038    | .0168       | .0134      | .0034      | .69       | .0050       | .0000     | .3214            | 1.6       |  |
| 15138   | Sept 9              | Distinct.   | Slight.   | .15    | 4.25                    | 1.40              | .0000    | .0194       | .0150      | .0044      | .65       | .0000       | .0000     | .3861            | 1.6       |  |
| 15721   | Dec. 10             | Distinct.   | Cons.     | .25    | 4.65                    | 1.55              | .0016    | .0158       | .0146      | .0012      | .69       | .0100       | .0000     | .3280            | 1.8       |  |
| Avg.    | .....               | .....       | .....     | .18    | 4.46                    | 1.50              | .0023    | .0166       | .0140      | .0026      | .71       | .0087       | .0000     | .3240            | 1.7       |  |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | .17 | 3.73 | 0.91 | .0006 | .0174 | -     | -     | .51 | .0043 | -     | -     | -   |
| - | 1888† | - | - | .13 | 3.69 | 0.92 | .0009 | .0167 | -     | -     | .48 | .0080 | .0001 | -     | -   |
| - | 1889‡ | - | - | .10 | 3.60 | 0.87 | .0009 | .0141 | .0119 | .0022 | .49 | .0163 | .0002 | -     | -   |
| - | 1890§ | - | - | .25 | 4.22 | 1.35 | .0001 | .0371 | .0190 | .0181 | .46 | .0090 | .0001 | -     | 1.8 |
| - | 1891  | - | - | .08 | 4.17 | 1.50 | .0003 | .0160 | .0129 | .0031 | .47 | .0145 | .0001 | -     | 1.6 |
| - | 1893  | - | - | .14 | 3.81 | 1.27 | .0028 | .0164 | .0141 | .0023 | .57 | .0108 | .0001 | .2638 | 1.6 |
| - | 1894  | - | - | .16 | 4.39 | 1.26 | .0011 | .0155 | .0136 | .0019 | .67 | .0105 | .0001 | .2371 | 1.8 |
| - | 1895  | - | - | .18 | 4.46 | 1.50 | .0023 | .0166 | .0140 | .0026 | .71 | .0087 | .0000 | .3240 | 1.7 |

\* June to December.

† January to October.

‡ January, March and June.

§ Three in October.

|| May and November.

NOTE to analyses of 1895: Odor of the first sample, faintly vegetable; of the second, distinctly vegetable and grassy; of the third, none; of the fourth, decided. — The samples were collected from a faucet at the pumping station.

## WAKEFIELD AND STONEHAM.

*Microscopical Examination of Water from Crystal Lake, Wakefield.*

[Number of organisms per cubic centimeter.]

|                               | 1895.    |            |            |            |
|-------------------------------|----------|------------|------------|------------|
|                               | March.   | June.      | September. | December.  |
| Day of examination, . . . . . | 14       | 14         | 13         | 12         |
| Number of sample, . . . . .   | 13974    | 14472      | 15138      | 15721      |
| <b>PLANTS.</b>                |          |            |            |            |
| Diatomaceæ, . . . . .         | 2        | 35         | 52         | 162        |
| Asterionella, . . . . .       | 1        | 0          | 36         | 132        |
| Cyclotella, . . . . .         | 0        | 29         | 0          | 3          |
| Fragilaria, . . . . .         | 0        | 4          | 0          | 0          |
| Melosira, . . . . .           | 0        | 0          | 9          | 23         |
| Synedra, . . . . .            | 0        | 0          | 2          | 1          |
| Tabellaria, . . . . .         | 1        | 2          | 5          | 18         |
| Cyanophyceæ, . . . . .        | 0        | 75         | 0          | 1          |
| Anabaena spores, . . . . .    | 0        | 23         | 0          | 0          |
| Microcystis, . . . . .        | 0        | 52         | 0          | 1          |
| Algae, . . . . .              | 0        | 6          | 4          | 0          |
| Protooccus, . . . . .         | 0        | 6          | 0          | 0          |
| Raphidium, . . . . .          | 0        | 0          | 4          | 0          |
| Fungi, Molds, . . . . .       | 0        | 6          | 0          | 0          |
| <b>ANIMALS.</b>               |          |            |            |            |
| Infusoria, . . . . .          | 0        | 0          | 1          | 2          |
| Cryptomonas, . . . . .        | 0        | 0          | 0          | 1          |
| Peridinium, . . . . .         | 0        | 0          | 0          | 1          |
| Trachelomonas, . . . . .      | 0        | 0          | 1          | 0          |
| Vermes, . . . . .             | 0        | 1          | 1          | 0          |
| Anura, . . . . .              | 0        | 0          | 1          | 0          |
| Rotifer, . . . . .            | 0        | 1          | 0          | 0          |
| Miscellaneous, . . . . .      | 0        | 39         | 0          | .04        |
| Acarina, . . . . .            | 0        | 0          | 0          | .04        |
| Zoöglon, . . . . .            | 0        | 39         | 0          | 0          |
| <b>TOTAL, . . . . .</b>       | <b>2</b> | <b>162</b> | <b>53</b>  | <b>185</b> |

## WALPOLE.

The advice of the State Board of Health to the town of Walpole relative to the introduction of a public water supply from the ground in the valley of Low Brook, a short distance above its junction with the Neponset River, may be found on pages 50 and 51 of this volume. The analysis of a sample of water taken from test wells in the vicinity of the brook, below Washington Street, is here given.

Works for supplying the town of Walpole with water taken from the ground in this vicinity were nearly completed at the end of 1895.

**WALPOLE.****Chemical Examination of Water from a Group of Tubular Test Wells in the Valley of Low Brook, Walpole.**

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 10205   | 1898.<br>Apr. 17    | None.       | None.     | .00    | 5.00                    | .0000    | .0014       | .20       | .0000       | .0000     | .41N             | 1.3       | .0020 |

Odor, none. — The sample was collected from a pump drawing water from seven tubular test wells in the valley of Low Brook, just below Washington Street.

**Microscopical Examination.**

No organisms.

**WATER SUPPLY OF WALTHAM.****Chemical Examination of Water from the Well and Filter-basin of the Waltham Water Works.**

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 13692   | 1893.<br>Jan. 15    | None.       | None.      | .00    | 7.20                    | .0034    | .0028       | .50       | .0170       | .0000     | .0553            | 3.2       | .0040 |
| 13794   | Feb. 11             | None.       | Slight.    | .01    | 9.80                    | .0042    | .0024       | .53       | .0150       | .0000     | .0608            | 3.6       | .0070 |
| 13930   | Feb. 18             | None.       | None.      | .00    | 7.30                    | .0038    | .0032       | .52       | .0150       | .0000     | .0488            | 3.4       | .0060 |
| 14164   | April 17            | None.       | None.      | .02    | 6.70                    | .0024    | .0016       | .52       | .0220       | .0000     | .0750            | 3.2       | .0100 |
| 14312   | May 16              | None.       | None.      | .04    | 8.45                    | .0032    | .0016       | .52       | .0220       | .0000     | .0513            | 3.0       | .0070 |
| 14470   | June 18             | None.       | None.      | .02    | 7.05                    | .0100    | .0024       | .51       | .0150       | .0000     | .0351            | 3.4       | .0100 |
| 14696   | July 22             | None.       | None.      | .04    | 6.60                    | .0018    | .0026       | .55       | .0300       | .0000     | .0800            | 3.5       | .0090 |
| 14857   | Aug. 19             | None.       | None.      | .01    | 7.10                    | .0034    | .0034       | .54       | .0180       | .0000     | .0546            | 3.4       | .0100 |
| 15194   | Sept. 17            | None.       | None.      | .05    | 7.40                    | .0020    | .0014       | .51       | .0220       | .0000     | .0507            | 3.4       | .0060 |
| 15356   | Oct. 14             | None.       | V. slight. | .05    | 7.60                    | .0034    | .0020       | .55       | .0170       | .0000     | .0725            | 3.9       | .0145 |
| 15557   | Nov. 18             | None.       | None.      | .02    | 7.10                    | .0032    | .0022       | .56       | .0150       | .0000     | .0507            | 3.4       | .0075 |
| 15730   | Dec. 16             | None.       | None.      | .07    | 6.95                    | .0030    | .0034       | .51       | .0250       | .0000     | .0462            | 3.5       | .0055 |
| Avg.*   | .....               | .....       | .....      | .08    | 7.15                    | .0036    | .0024       | .53       | .0198       | .0000     | .0550            | 3.4       | .0082 |

**Averages by Years.**

|   |       |   |   |     |      |       |       |     |       |       |       |     |       |
|---|-------|---|---|-----|------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1897† | - | - | .00 | 6.71 | .0007 | .0038 | .47 | .0250 | -     | -     | -   | -     |
| - | 1898  | - | - | .00 | 6.70 | .0009 | .0064 | .46 | .0273 | .0003 | -     | -   | -     |
| - | 1899‡ | - | - | .00 | 6.48 | .0006 | .0034 | .48 | .0378 | .0002 | -     | -   | -     |
| - | 1900§ | - | - | .00 | -    | .0000 | .0012 | .47 | .0380 | .0002 | -     | -   | -     |
| - | 1902  | - | - | .00 | 6.81 | .0033 | .0027 | .48 | .0162 | .0000 | -     | 3.4 | -     |
| - | 1903  | - | - | .01 | 6.86 | .0086 | .0022 | .47 | .0179 | .0000 | .0643 | 3.4 | .0020 |
| - | 1904  | - | - | .02 | 6.75 | .0023 | .0019 | .51 | .0192 | .0000 | .0408 | 3.1 | .0044 |
| - | 1905  | - | - | .08 | 7.16 | .0036 | .0024 | .53 | .0198 | .0000 | .0550 | 3.4 | .0082 |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

† June to December.

‡ January to May.

§ July.

NOTE to analyses of 1905: Odor, none. — The samples collected in January, February and October were taken from the filter-basin, and the other samples from a faucet at the pumping station.

**Microscopical Examination.**

*Oreothrix* was present in seven of these samples, the highest number found in any sample being 88, in December. No. 4164 was not examined. No organisms were found in the other samples.

## WALTHAM.

*Chemical Examination of Water from the Distributing Reservoir of the Waltham Water Works.*[Parts per 100,000.]<sup>1</sup>

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 13663   | 1895.<br>Jan. 15    | V. slight.  | V. slight. | .03    | 6.80                    | .0002    | .0064       | .54       | .0180       | .0000     | .0750            | 3.2       | .0000 |
| 13837   | Feb. 18             | V. slight.  | Cons.      | .00    | 6.60                    | .0008    | .0134       | .53       | .0100       | .0000     | .1209            | 3.4       | .0030 |
| 14165   | Apr. 17             | None.       | Slight.    | .02    | 6.70                    | .0020    | .0026       | .42       | .0230       | .0000     | .0671            | 3.4       | .0060 |
| 14313   | May 16              | Distinct.   | Slight.    | .03    | 6.75                    | .0008    | .0226       | .56       | .0050       | .0000     | .0987            | 3.0       | .0035 |
| 14480   | June 18             | Distinct.   | Slight.    | .02    | 6.75                    | .0008    | .0154       | .53       | .0070       | .0001     | .1092            | 3.2       | .0010 |
| 14665   | July 22             | None.       | V. slight. | .04    | 7.05                    | .0024    | .0050       | .54       | .0350       | .0000     | .0600            | 3.4       | .0125 |
| 14856   | Aug. 19             | V. slight.  | Slight.    | .02    | 7.80                    | .0038    | .0030       | .54       | .0100       | .0001     | .0702            | 3.5       | .0050 |
| 15195   | Sept. 17            | Decided.    | Slight.    | .12    | 7.55                    | .0010    | .0078       | .53       | .0130       | .0003     | .1108            | 3.4       | .0060 |
| 15357   | Oct. 14             | V. slight.  | Slight.    | .05    | 6.85                    | .0000    | .0078       | .53       | .0180       | .0000     | .1014            | 3.2       | .0070 |
| 15558   | Nov. 18             | V. slight.  | V. slight. | .02    | 7.15                    | .0034    | .0028       | .56       | .0180       | .0000     | .0780            | 3.4       | .0035 |
| 15731   | Dec. 16             | Distinct.   | Slight.    | .05    | 6.95                    | .0026    | .0064       | .52       | .0200       | .0000     | .0554            | 3.5       | .0025 |
| Av.     | .....               | .....       | .....      | .04    | 7.00                    | .0016    | .0085       | .53       | .0161       | .0000     | .0861            | 3.3       | .0045 |

*Averages by Years.*

|   |       |   |   |     |      |       |       |     |       |       |       |     |       |
|---|-------|---|---|-----|------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1887* | - | - | .00 | 6.66 | .0007 | .0061 | .46 | .0197 | -     | -     | -   | -     |
| - | 1888  | - | - | .00 | 6.45 | .0003 | .0075 | .46 | .0248 | .0003 | -     | -   | -     |
| - | 1889† | - | - | .00 | 6.21 | .0003 | .0078 | .47 | .0280 | .0003 | -     | -   | -     |
| - | 1890‡ | - | - | .00 | -    | .0000 | .0124 | .47 | .0280 | .0001 | -     | -   | -     |
| - | 1891§ | - | - | .00 | 6.25 | .0000 | .0044 | .40 | .0200 | .0000 | -     | 3.0 | -     |
| - | 1892  | - | - | .01 | 6.28 | .0006 | .0082 | .44 | .0119 | .0001 | -     | 3.0 | -     |
| - | 1893  | - | - | .04 | 6.72 | .0006 | .0074 | .47 | .0127 | .0001 | .1033 | 3.1 | .0019 |
| - | 1894  | - | - | .03 | 6.80 | .0007 | .0140 | .51 | .0078 | .0001 | .0926 | 3.1 | .0032 |
| - | 1895  | - | - | .04 | 7.00 | .0016 | .0085 | .53 | .0161 | .0000 | .0861 | 3.3 | .0045 |

\* June to December.

† January to May.

‡ February.

§ May.

NOTE to analyses of 1895: Odor, none, except in June and July, when it was unpleasant; on heating, a faintly grassy or unpleasant odor was developed in some of the samples. — The samples were collected from the reservoir.

**WALTHAM.*****Microscopical Examination of Water from the Distributing Reservoir of the Waltham Water Works.***

[Number of organisms per cubic centimeter.]

|                                 | 1895. |        |       |       |       |       |       |       |       |       |       |  |
|---------------------------------|-------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--|
|                                 | Jan.  | Feb.   | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |  |
| Day of examination, . . . .     | 16    | 20     | -     | 17    | 19    | 24    | 20    | 19    | 15    | 20    | 18    |  |
| Number of sample, . . . .       | 13663 | 13837  | 14165 | 14313 | 14480 | 14665 | 14856 | 15195 | 15357 | 15558 | 15731 |  |
| PLANTS.                         |       |        |       |       |       |       |       |       |       |       |       |  |
| Diatomaceæ, . . . .             | 1,463 | 10,800 | -     | 588   | 162   | 0     | 142   | 0     | 1     | 371   | 5,612 |  |
| Asterionella, . . . .           | 43    | 240    | -     | 380   | 0     | 0     | 0     | 0     | 0     | 368   | 5,800 |  |
| Cyclotella, . . . .             | 0     | 0      | -     | 0     | 87    | 0     | 2     | 0     | 0     | 0     | 0     |  |
| Synedra, . . . .                | 1,420 | 10,560 | -     | 208   | 75    | 0     | 140   | 0     | 1     | 3     | 12    |  |
| Cyanophyceæ, Oscillaria, .      | 0     | 0      | -     | 0     | 0     | 18    | 0     | 0     | 0     | 0     | 0     |  |
| Fungi, . . . .                  | 17    | 5      | -     | 1,620 | 3,000 | 46    | 3     | 0     | 0     | 0     | 3     |  |
| Crenothrix, . . . .             | 5     | 5      | -     | 0     | 0     | 0     | 3     | 0     | 0     | 0     | 3     |  |
| Leptothrix, . . . .             | 12    | 0      | -     | 1,620 | 3,000 | 46    | 0     | 0     | 0     | 0     | 0     |  |
| ANIMALS.                        |       |        |       |       |       |       |       |       |       |       |       |  |
| Infusoria, . . . .              | 7     | 3      | -     | 0     | 22    | 19    | 1     | 0     | 0     | 0     | 0     |  |
| Dinobryon, . . . .              | 0     | 0      | -     | 0     | 22    | 19    | 0     | 0     | 0     | 0     | 0     |  |
| Monas, . . . .                  | 0     | 2      | -     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |  |
| Peridinium, . . . .             | 7     | 1      | -     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 0     |  |
| Miscellaneous, Zoöglæa, . . . . | 0     | 0      | -     | 0     | 0     | 0     | 0     | 0     | 20    | 0     | 0     |  |
| TOTAL, . . . .                  | 1,487 | 10,808 | -     | 2,208 | 3,184 | 83    | 146   | 0     | 21    | 371   | 5,615 |  |

**WATER SUPPLY OF WARE.*****Chemical Examination of Water from a Faucet at the Pumping Station of the Ware Water Works.***

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albu- minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 15228   | 1895.<br>Sept. 21   | None.       | None.     | .00    | 5.10                    | .0000    | .0000         | .28       | .0570       | .0000     | .0234            | 1.0       | .6020 |

## WARE.

*Chemical Examination of Water from a Faucet at the Pumping Station of the Ware Water Works—Concluded.**Averages by Years.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 1887*               | -           | -         | .00    | 7.05                    | .0001    | .0011       | 0.50      | .2663       | -         | -                | -         | -     |
| 1888                | -           | -         | .00    | 7.58                    | .0000    | .0011       | 1.35      | .3262       | .0002     | -                | -         | -     |
| 1889†               | -           | -         | .00    | 8.14                    | .0001    | .0013       | 0.89      | .3111       | .0000     | -                | -         | -     |
| 1890‡               | -           | -         | .00    | -                       | .0002    | .0014       | 0.95      | .3400       | .0000     | -                | -         | -     |
| 1891§               | -           | -         | .00    | 11.70                   | .0000    | .0000       | 1.44      | .7000       | .0000     | -                | 3.9       | -     |
| 1892                | -           | -         | .00    | 10.53                   | .0000    | .0008       | 1.15      | .5665       | .0000     | -                | 3.8       | -     |
| 1893¶               | -           | -         | .00    | 11.08                   | .0002    | .0015       | 1.04      | .4750       | .0000     | .0447            | 3.7       | .0035 |
| 1894                | -           | -         | .00    | 5.25                    | .0014    | .0006       | 0.27      | .1000       | .0000     | .0065            | 2.0       | .0010 |
| 1895**              | -           | -         | .00    | 5.10                    | .0000    | .0000       | 0.28      | .0570       | .0000     | .0234            | 1.9       | .0020 |

\* June to November.

† January to June.

‡ February.

§ November.

|| February, July and December.

¶ February and August.

\*\* September.

NOTE to analyses of 1895: Odor, none. — The sample was collected from a faucet at the pumping station, while pumping from the large well and tubular wells.

*Microscopical Examination.*

No organisms.

## WASHINGTON.

*Chemical Examination of Water from West Pond and Roaring Brook, Washington.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |             |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Sus-pended. |           |             |           |                  |           |
| 1895.   |                     |             |           |        |                         |                   |          |             |            |             |           |             |           |                  |           |
| 14822   | Aug. 11             | Distinct.   | Slight.   | 1.80   | 6.20                    | 4.15              | .0032    | .0446       | .0394      | .0052       | .07       | .0020       | .0002     | 2.3400           | 1.6       |
| 15722   | Dec. 10             | V. slight.  | Slight.   | 1.30   | 5.40                    | 3.15              | .0006    | .0352       | .0334      | .0018       | .04       | .0050       | .0000     | 1.6185           | 1.4       |
| 15857   | Jan. 3              | None.       | Slight.   | 1.20   | 4.30                    | 2.60              | .0002    | .0228       | .0212      | .0016       | .04       | .0130       | .0000     | 1.5400           | 1.3       |
| 15838   | Jan. 3              | None.       | Slight.   | 1.30   | 4.60                    | 2.90              | .0000    | .0262       | .0240      | .0022       | .05       | .0130       | .0000     | 1.7440           | 1.1       |

Odor of the first two and last samples, vegetable; of the third sample, none. — The first sample was collected from West Pond, near its centre; the second and last samples, from Roaring Brook, near the outlet of West Pond; the third sample, from Roaring Brook, at the first road crossing below West Pond. The samples were collected during an investigation relative to an additional water supply for Pittsfield.

*Microscopical Examination.*

No. 14822. Diatomaceæ, *Cocconeis*, 12; *Cyclotella*, 760; *Synedra*, 60; *Tabellaria*, 12. Cyanophyceæ, *Merismopedia*, 8; *Microcystis*, 2; *Oscillatoria*, 2. Algeæ, *Conserva*, 8; *Glucocapsa*, 1; *Pediastrum*, 2; *Prolococcus*, 26; *Raphidium*, 4; *Scenedesmus*, 7. Fungi, *Orenothrix*, 6. Infusoria, *Dinobryon caeca*, 68; *Peridinium*, 2; *Phacus*, 1; *Trachelomonas*, 3. Vermes, *Anurea*, 8; *Rotatorian ova*, 1. Miscellaneous, *Zoëglæa*, 30. Total, 1,018.

No. 15722. Diatomaceæ, *Cymbella*, 1; *Meridion*, 1; *Synedra*, 1. Miscellaneous, *Zoëglæa*, 3. Total, 6.

Nos. 15837 and 15838 were not examined microscopically.

## WATERTOWN AND BELMONT.

WATER SUPPLY OF WATERTOWN AND BELMONT. — WATERTOWN  
WATER SUPPLY COMPANY.*Chemical Examination of Water from a Faucet in the Pumping Station of the  
Watertown Water Supply Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                |        | Residue on Evaporation. | AMMONIA. |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|----------------|--------|-------------------------|----------|-----------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment.      | Color. |                         | Free.    | Alb-<br>minold. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1895.</b>        |                  |                |        |                         |          |                 |           |             |           |                  |           |       |
| 13664   | Jan. 14             | Slight, milky.   | Slight.        | .05    | 9.60                    | .0046    | .0074           | .74       | .1400       | .0000     | .1066            | 4.0       | .0240 |
| 13995   | Mar. 18             | V. slight.       | Slight, flocc. | .10    | 6.20                    | .0018    | .0060           | .55       | .0650       | .0000     | .1540            | 3.4       | .0180 |
| 14159   | Apr. 15             | None.            | V. slight.     | .10    | 7.60                    | .0014    | .0064           | .64       | .0950       | .0000     | .1501            | 3.1       | .0200 |
| 14311   | May 15              | Slight.          | V. slight.     | .18    | 7.80                    | .0064    | .0052           | .62       | .0500       | .0000     | .1145            | 3.4       | .0570 |
| 14493   | June 18             | Distinct, milky. | None.          | .25    | 8.70                    | .0098    | .0072           | .60       | .0300       | .0000     | .1365            | 3.4       | .0580 |
| 14715   | July 25             | Slight, milky.   | Slight, rusty. | .28    | 8.20                    | .0094    | .0086           | .75       | .0350       | .0000     | .2002            | 4.0       | .0650 |
| 14873   | Aug. 19             | Slight, milky.   | Slight, rusty. | .18    | 9.70                    | .0090    | .0044           | .70       | .0470       | .0000     | .1248            | 3.8       | .0620 |
| 15182   | Sept. 17            | Distinct, milky. | Slight, rusty. | .38    | 11.40                   | .0012    | .0088           | .79       | .0280       | .0000     | .2106            | 5.6       | .0920 |
| 15375   | Oct. 14             | Distinct.        | Cons., flocc.  | .30    | 10.90                   | .0046    | .0128           | .71       | .1200       | .0007     | .2168            | 4.3       | .1000 |
| 15574   | Nov. 18             | Distinct, milky. | V. slight.     | .22    | 7.40                    | .0028    | .0092           | .74       | .0380       | .0004     | .2145            | 2.9       | .0300 |
| 15756   | Dec. 16             | Distinct.        | V. slight.     | .15    | 8.80                    | .0046    | .0090           | .73       | .0850       | .0018     | .1247            | 3.2       | .0540 |
| Av.     | .....               | .....            | .....          | .20    | 8.75                    | .0051    | .0077           | .69       | .0669       | .0003     | .1594            | 3.7       | .0527 |

*Averages by Years.*

|   |       |   |   |     |      |       |       |     |       |       |       |     |       |
|---|-------|---|---|-----|------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1887* | - | - | .00 | 7.09 | .0005 | .0034 | .65 | .0300 | -     | -     | -   | -     |
| - | 1888  | - | - | .00 | 7.22 | .0000 | .0040 | .63 | .0647 | .0000 | -     | -   | -     |
| - | 1889† | - | - | .00 | 6.45 | .0000 | .0027 | .64 | .0642 | .0000 | -     | -   | -     |
| - | 1890‡ | - | - | .00 | 7.40 | .0014 | .0042 | .69 | .0450 | .0000 | -     | 3.9 | -     |
| - | 1892§ | - | - | .07 | 7.90 | .0041 | .0046 | .66 | .0370 | .0001 | -     | 4.0 | .0396 |
| - | 1893  | - | - | .19 | 7.95 | .0063 | .0061 | .66 | .0489 | .0001 | .1275 | 3.5 | .0315 |
| - | 1894  | - | - | .11 | 8.82 | .0048 | .0054 | .70 | .0542 | .0001 | .1224 | 3.8 | .0516 |
| - | 1895  | - | - | .20 | 8.75 | .0051 | .0077 | .69 | .0600 | .0003 | .1594 | 3.7 | .0527 |

\* June to December.

† January to May.

‡ August.

§ September to December.

NOTE to analyses of 1895: Odor, generally none; in July, distinctly vegetable; in September, November and December, faintly vegetable. — The samples were collected from a faucet at the pumping station.

## WATERTOWN AND BELMONT.

*Microscopical Examination of Water from a Faucet in the Pumping Station of the Watertown Water Supply Company.*

[Number of organisms per cubic centimeter.]

|                                   | 1893. |       |       |       |       |       |       |       |       |       |       |  |
|-----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--|
|                                   | Jan.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |  |
| Day of examination, . . . . .     | 16    | 20    | 17    | 17    | 20    | 27    | 21    | 18    | 17    | 20    | 20    |  |
| Number of sample, . . . . .       | 13664 | 13995 | 14159 | 14311 | 14493 | 14715 | 14873 | 15182 | 15375 | 15574 | 15756 |  |
| PLANTS.                           |       |       |       |       |       |       |       |       |       |       |       |  |
| Algæ, Protococcus, . . . . .      | 0     | 0     | 8     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |  |
| Fungi, . . . . .                  | 176   | 24    | 11    | 680   | 54    | 72    | 54    | 18    | 33    | 160   | 10    |  |
| Crenothrix, . . . . .             | 176   | 24    | 11    | 680   | 54    | 44    | 54    | 18    | 28    | 160   | 10    |  |
| Molds, . . . . .                  | 0     | 0     | 0     | 0     | 0     | 28    | 0     | 0     | 6     | 0     | 0     |  |
| Miscellaneous, Zoöglæa, . . . . . | 0     | 0     | 0     | 16    | 0     | 0     | 18    | 0     | 100   | 1     | 0     |  |
| TOTAL, . . . . .                  | 176   | 24    | 17    | 696   | 54    | 72    | 72    | 18    | 133   | 161   | 10    |  |

*Chemical Examination of Water from a Faucet in Watertown, supplied from the Works of the Watertown Water Supply Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |                |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------------|----------------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.        | Sediment.      | Color. |                         | Free.    | Albu- minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | 1895.               |                   |                |        |                         |          |               |           |             |           |                  |           |       |
| 13610   | Jan. 7              | V. slight, milky. | None.          | .08    | 9.80                    | .0002    | .0042         | .74       | .0800       | .0000     | .0624            | 4.6       | .0220 |
| 13779   | Feb. 6              | None.             | None.          | .02    | 8.70                    | .0002    | .0048         | .70       | .1500       | .0000     | .0987            | 4.0       | .0140 |
| 13916   | Mar. 6              | None.             | None.          | .05    | 9.50                    | .0000    | .0036         | .70       | .0980       | .0000     | .0708            | 4.6       | .0240 |
| 14090   | Apr. 3              | None.             | None.          | .08    | 8.60                    | .0006    | .0038         | .59       | .1030       | .0000     | .0770            | 3.6       | .0170 |
| 14256   | May 7               | None.             | None.          | .08    | 9.00                    | .0000    | .0048         | .66       | .0630       | .0000     | .0639            | 3.8       | .0130 |
| 14432   | June 5              | Slight, milky.    | None.          | .05    | 8.70                    | .0002    | .0046         | .62       | .0480       | .0000     | .0707            | 4.0       | .0180 |
| 14604   | July 10             | None.             | V. slight.     | .08    | 9.70                    | .0004    | .0048         | .70       | .0930       | .0000     | .1027            | 4.4       | .0120 |
| 14783   | Aug. 7              | V. slight, milky. | V. slight.     | .10    | 9.50                    | .0028    | .0040         | .71       | .0500       | .0006     | .1014            | 6.4       | .0250 |
| 14990   | Sept. 4             | Slight, milky.    | None.          | .20    | 11.20                   | .0124    | .0062         | .79       | .0200       | .0003     | .1655            | 5.6       | .0500 |
| 15320   | Oct. 7              | Distinct, milky.  | None.          | .25    | 10.60                   | .0048    | .0054         | .80       | .0250       | .0002     | .1621            | 5.3       | .0430 |
| 15498   | Nov. 6              | Slight, milky.    | None.          | .15    | 9.90                    | .0000    | .0066         | .69       | .0580       | .0000     | .1264            | 4.3       | .0180 |
| 15677   | Dec. 4              | Slight, milky.    | None.          | .12    | 7.90                    | .0000    | .0058         | .68       | .0720       | .0000     | .1209            | 3.8       | .0120 |
| 15761   | Dec. 17             | Decided, milky.   | Slight, rusty. | .63    | 10.30                   | .0000    | .0106         | .64       | .1000       | .0001     | .1732            | 4.4       | .2250 |
| Av.*    | .....               | .....             | .....          | .13    | 9.52                    | .0018    | .0051         | .75       | .0678       | .0001     | .1032            | 4.6       | .0312 |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.



**WATERTOWN AND BELMONT.**

*Chemical Examination of Water from a Faucet in Watertown, supplied from the Works of the Watertown Water Supply Company — Concluded.*

*Averages by Years.*

[Parts per 100,000.]

| Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------------------|-------------|-----------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albu- minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 1893                | -           | -         | .09    | 8.06                    | .0012    | .0052         | .61       | .0426       | .0001     | .1322            | 3.7       | .0165 |
| 1894                | -           | -         | .11    | 9.32                    | .0001    | .0042         | .71       | .0490       | .0000     | .0976            | 4.6       | .0177 |
| 1895                | -           | -         | .13    | 9.52                    | .0018    | .0051         | .75       | .0678       | .0001     | .1032            | 4.6       | .0312 |

NOTE to analyses of 1895: Odor, generally none; on September 4 and December 17, faintly vegetable; in October, faintly oily. — The samples were collected from a faucet in a house in the easterly part of Watertown.

*Microscopical Examination.*

Orenothrix was found in eight of these samples, the highest number being 640 in the last sample, and the next highest 76, in No. 14990.

*Chemical Examination of Water from Faucets in Watertown, supplied from the Works of the Watertown Water Supply Company.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                |        | Residue on Evaporation. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|----------------|--------|-------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment.      | Color. |                         | Free.    | Albu- minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 13838   | 1895.<br>Feb. 18    | None.            | None.          | .10    | 8.90                    | .0008    | .0042         | .76       | .1100       | .0000     | .0624            | 4.0       | .0230 |
| 15137   | Sept. 9             | Slight, milky.   | Slight.        | .25    | 11.90                   | .0102    | .0064         | .76       | .0050       | .0016     | .2340            | 5.7       | .0600 |
| 15168   | Sept. 13            | Distinct, milky. | Slight, rusty. | .40    | 10.00                   | .0156    | .0084         | .70       | .0170       | .0010     | .2278            | 4.4       | .0760 |

Odor of the first sample, none; of the others, faintly vegetable.

*Microscopical Examination.*

An insignificant number of organisms was found in each of these samples.

WAYLAND.

WATER SUPPLY OF WAYLAND.

Chemical Examination of Water from the Wayland Water Works.

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 13891   | 1895.<br>Feb. 26    | Slight.     | Slight.   | 0.37   | 4.55                    | .0018    | .0092       | .54       | .0230       | .0002     | 0.3097           | 1.9       | .0475 |
| 14529   | June 24             | Slight.     | Slight.   | 1.10   | 4.60                    | .0046    | .0292       | .31       | .0050       | .0001     | 0.8662           | 1.9       | -     |
| 15472   | Nov. 3              | Slight.     | Slight.   | 1.30   | 5.25                    | .0014    | .0294       | .40       | .0200       | .0002     | 1.4664           | 1.7       | -     |
| Av.     | .....               | .....       | .....     | 0.92   | 4.80                    | .0026    | .0226       | .42       | .0160       | .0002     | 0.8808           | 1.8       | -     |

Odor, distinctly vegetable. — The first sample was collected from a faucet on the main pipe, and the others from a faucet in the gate-house.

Microscopical Examination of Water from the Wayland Water Works.

[Number of organisms per cubic centimeter.]

|                                   | 1893.     |       |           |
|-----------------------------------|-----------|-------|-----------|
|                                   | February. | June. | November. |
| Day of examination, . . . . .     | 28        | 25    | 6         |
| Number of sample, . . . . .       | 13891     | 14529 | 15472     |
| PLANTS.                           |           |       |           |
| Diatomaceæ, . . . . .             | 0         | 45    | 31        |
| Asterionella, . . . . .           | 0         | 0     | 8         |
| Melosira, . . . . .               | 0         | 34    | 14        |
| Navicula, . . . . .               | 0         | 1     | 3         |
| Synedra, . . . . .                | 0         | 8     | 6         |
| Tabellaria, . . . . .             | 0         | 2     | 0         |
| Algæ, . . . . .                   | 0         | 2     | 2         |
| Cosmarium, . . . . .              | 0         | 0     | 2         |
| Staurastrum, . . . . .            | 0         | 2     | 0         |
| Fungi, Crenothrix, . . . . .      | 2,912     | 11    | 7         |
| ANIMALS.                          |           |       |           |
| Infusoria, . . . . .              | 0         | 70    | 12        |
| Dinobryon, . . . . .              | 0         | 10    | 0         |
| Dinobryon cases, . . . . .        | 0         | 60    | 7         |
| Mallomonas, . . . . .             | 0         | 0     | 1         |
| Peridinium, . . . . .             | 0         | 0     | 2         |
| Trachelomonas, . . . . .          | 0         | 0     | 2         |
| Miscellaneous, Zoöglæa, . . . . . | 0         | 0     | 80        |
| TOTAL, . . . . .                  | 2,912     | 128   | 112       |

## WEBSTER.

## WATER SUPPLY OF WEBSTER.

*Chemical Examination of Water from the Well of the Webster Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.    |                |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|----------------|----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.     | Sediment.      | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         | <b>1895.</b>        |                |                |        |                         |          |             |           |             |           |                  |           |       |
| 13668   | Jan. 15             | Slight, rusty. | Slight, rusty. | .10    | 3.40                    | .0000    | .0006       | .21       | .0280       | .0000     | .0079            | 1.3       | .0400 |
| 13854   | Feb. 19             | Slight.        | Slight.        | .00    | 4.00                    | .0000    | .0000       | .20       | .0180       | .0000     | .0000            | 1.1       | .0000 |
| 13956   | Mar. 11             | None.          | None.          | .00    | 3.80                    | .0000    | .0010       | .21       | .0100       | .0000     | .0139            | 1.3       | .0000 |
| 14109   | Apr. 8              | None.          | None.          | .00    | 4.80                    | .0000    | .0040       | .21       | .0250       | .0000     | .0000            | 1.3       | .0020 |
| 14271   | May 8               | None.          | Slight.        | .00    | 3.50                    | .0000    | .0014       | .23       | .0300       | .0000     | .0000            | 1.7       | .0000 |
| 14447   | June 11             | None.          | None.          | .00    | 4.10                    | .0004    | .0008       | .23       | .0220       | .0000     | .0195            | 1.7       | .0020 |
| 14627   | July 15             | None.          | None.          | .00    | 5.00                    | .0000    | .0012       | .21       | .0220       | .0000     | .0234            | 2.2       | .0030 |
| 14817   | Aug. 12             | None.          | None.          | .00    | 6.25                    | .0000    | .0010       | .22       | .0130       | .0001     | .0468            | 2.5       | .0000 |
| 15105   | Sept. 9             | None.          | None.          | .00    | 4.60                    | .0000    | .0014       | .21       | .0180       | .0000     | .0507            | 1.9       | .0000 |
| 15334   | Oct. 8              | None.          | V. slight.     | .00    | 3.40                    | .0000    | .0000       | .24       | .0150       | .0000     | .0351            | 1.4       | .0000 |
| 15511   | Nov. 11             | None.          | None.          | .00    | 3.20                    | .0000    | .0000       | .25       | .0300       | .0000     | .0140            | 1.1       | .0000 |
| 15695   | Dec. 9              | None.          | None.          | .00    | 2.70                    | .0000    | .0002       | .26       | .0480       | .0000     | .0039            | 1.1       | .0050 |
| Av.     | 1895                | .....          | .....          | .00    | 4.13                    | .0000    | .0010       | .22       | .0235       | .0000     | .0179            | 1.5       | .0043 |
| Av.     | 1894                | .....          | .....          | .01    | 3.43                    | .0001    | .0006       | .21       | .0232       | .0000     | .0103            | 1.4       | .0032 |

NOTE to analyses of 1895: Odor, none except in May, when it was very faintly unpleasant, becoming vegetable on heating. — The first two samples were collected from a faucet at the pumping station, and the others from the well.

*Microscopical Examination.*No. 13668. Fungi, *Crenothrix*, 423.No. 14271. Diatomaceae, *Synedra*, 30. Miscellaneous, *Zoëglæa*, 22. Total, 52.

No. 13956 was not examined microscopically.

No organisms were found in the remaining samples.

## WELLESLEY.

## WATER SUPPLY OF WELLESLEY.

*Chemical Examination of Water from the Filter-gallery of the Wellesley Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |          | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrate.    | Nitrite. |                  |           |       |
| 14609   | 1895.<br>July 11    | None.       | Cons.     | .02    | 6.50                    | .0010    | .0038       | .62       | .0200       | .0000    | .0632            | 3.0       | .0000 |
| 14765   | Aug. 5              | None.       | Slight.   | .08    | 6.25                    | .0006    | .0066       | .70       | .0130       | .0000    | .1716            | 3.1       | .0050 |

*Averages by Years.*

|   |        |   |   |     |      |       |       |     |       |       |       |     |       |
|---|--------|---|---|-----|------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1887*  | - | - | .01 | 7.57 | .0002 | .0016 | .54 | .0079 | -     | -     | -   | -     |
| - | 1888   | - | - | .00 | 6.57 | .0001 | .0023 | .44 | .0639 | .0000 | -     | -   | -     |
| - | 1889†  | - | - | .00 | 5.89 | .0005 | .0021 | .39 | .0520 | .0000 | -     | -   | -     |
| - | 1890†  | - | - | .00 | 5.85 | .0002 | .0032 | .73 | .0400 | .0000 | -     | 4.0 | -     |
| - | 1892‡  | - | - | .00 | 7.90 | .0000 | .0000 | .53 | .0550 | .0000 | -     | 3.8 | .0000 |
| - | 1893   | - | - | .00 | 6.70 | .0000 | .0008 | .52 | .0600 | .0000 | .0657 | 2.8 | .0050 |
| - | 1894§  | - | - | .03 | 6.60 | .0008 | .0023 | .56 | .0465 | .0000 | .0369 | 2.9 | .0030 |
| - | 1895** | - | - | .05 | 6.38 | .0008 | .0052 | .66 | .0165 | .0000 | .1174 | 3.1 | .0025 |

\* June to December.

|| July.

† January to May.

‡ June and October.

§ September.

\*\* July and August.

§ October.

NOTE to analyses of 1895: Odor, none. — The samples were collected from the filter-gallery.

*Microscopical Examination.*No. 14609. Fungi, *Crenothrix*, 2.

No. 14765. No organisms.

*Chemical Examination of Water from the Well of the Wellesley Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |          | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrate.    | Nitrite. |                  |           |       |
| 14608   | 1895.<br>July 11    | None.       | None.     | .03    | 5.80                    | .0002    | .0060       | .66       | .0200       | .0000    | .1580            | 2.6       | .0010 |
| 14764   | Aug. 5              | None.       | Slight.   | .02    | 7.90                    | .0002    | .0056       | .62       | .0480       | .0000    | .0780            | 3.8       | .0010 |

*Averages by Years.*

|   |       |   |   |     |      |       |       |     |       |       |       |     |       |
|---|-------|---|---|-----|------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1890* | - | - | .00 | 6.15 | .0002 | .0052 | .73 | .1000 | .0001 | -     | 4.3 | -     |
| - | 1892† | - | - | .00 | 6.55 | .0000 | .0084 | .65 | .0950 | .0001 | -     | 2.4 | .0000 |
| - | 1893‡ | - | - | .00 | 5.90 | .0000 | .0014 | .60 | .0600 | .0000 | .0657 | 2.3 | .0100 |
| - | 1894§ | - | - | .03 | 6.10 | .0000 | .0032 | .69 | .0515 | .0000 | .0712 | 2.6 | .0015 |
| - | 1895  | - | - | .03 | 6.86 | .0002 | .0058 | .64 | .0340 | .0000 | .1180 | 3.2 | .0005 |

\* September.

† October.

‡ July.

§ June and October

|| July and August.

NOTE to analyses of 1895: Odor of the first sample, none; of the second, faintly unpleasant, disappearing on heating. — The samples were collected from the well at Williams Spring.

*Microscopical Examination.*

No organisms.

## WENHAM.

## WENHAM.

The advice of the State Board of Health to the town of Wenham relative to the use of water from Pleasant Pond in that town as a public water supply may be found on pages 51 and 52 of this volume. The results of the analysis of a sample of water from this pond are given below.

*Chemical Examination of Water from Pleasant Pond, Wenham.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |           |
| 13964   | 1895.<br>Mar. 11    | V. slight.  | V. slight. | .50    | 5.20                    | 1.80              | .0100    | .0190       | .0160      | .0030           | .82       | .0220       | .0003     | .5544            | 2.6       |

Odor, very faintly vegetable, becoming stronger on heating. — The sample was collected from the pond, near its outlet.

*Microscopical Examination.*

Infusoria, Dinobryon, 1; Dinobryon cases, 20; Peridinium, 1. Total, 22.

## WATER SUPPLY OF WESTBOROUGH.

*Chemical Examination of Water from the Upper Sandra Reservoir, Westborough.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.          |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|----------------------|-------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.           | Sediment.         | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                      |                   |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13682   | 1895.<br>Jan. 16    | Slight.              | Slight.           | .40    | 3.15                    | 1.05              | .0006    | .0142       | .0130      | .0012      | .29       | .0070       | .0000     | .4550            | 0.8       |
| 13978   | Mar. 13             | V. slight.           | Slight.           | .25    | 2.55                    | 1.10              | .0040    | .0128       | .0112      | .0016      | .20       | .0180       | .0000     | .4016            | 0.3       |
| 14295   | May 14              | Distinct.            | Cons.             | .23    | 2.75                    | 1.60              | .0004    | .0228       | .0154      | .0074      | .20       | .0030       | .0000     | .4108            | 0.3       |
| 14688   | July 23             | Decided.             | Slight.           | .28    | 3.70                    | 1.80              | .0000    | .0900       | .0334      | .0566      | .28       | .0000       | .0000     | .3825            | 0.6       |
| 15264   | Sept. 24            | Distinct.            | Slight,           | .15    | 3.60                    | 2.20              | .0338    | .0530       | .0448      | .0082      | .23       | .0030       | .0001     | .4719            | 0.2       |
| 15621   | Nov. 26             | green,<br>V. slight. | green,<br>Slight. | .50    | 2.80                    | 1.55              | .0084    | .0290       | .0234      | .0056      | .21       | .0030       | .0000     | .6609            | 0.5       |
| Av.     | 1895                | .....                | .....             | .30    | 3.09                    | 1.55              | .0079    | .0369       | .0235      | .0134      | .23       | .0057       | .0000     | .4648            | 0.4       |
| Av.     | 1894                | .....                | .....             | .30    | 3.32                    | 1.57              | .0061    | .0384       | .0200      | .0184      | .21       | .0023       | .0000     | .4714            | 0.4       |

NOTE to analyses of 1895: Odor, generally faintly vegetable, sometimes distinctly vegetable; in September, vegetable and disagreeable. On heating, an oily odor was developed in the first sample. — The samples were collected from the upper reservoir.

## WESTBOROUGH.

*Microscopical Examination of Water from the Upper Sandra Reservoir,  
Westborough.*

[Number of organisms per cubic centimeter.]

|                                     | 1895.     |            |            |               |            |            |
|-------------------------------------|-----------|------------|------------|---------------|------------|------------|
|                                     | Jan.      | Mar.       | May.       | July.         | Sept.      | Nov.       |
| Day of examination, . . . . .       | 17        | 16         | 15         | 24            | 28         | 27         |
| Number of sample, . . . . .         | 13682     | 13978      | 14295      | 14688         | 15264      | 15021      |
| <b>PLANTS.</b>                      |           |            |            |               |            |            |
| <b>Diatomaceæ, . . . . .</b>        | <b>1</b>  | <b>0</b>   | <b>243</b> | <b>50</b>     | <b>1</b>   | <b>208</b> |
| Melosira, . . . . .                 | 0         | 0          | 8          | 0             | 0          | 0          |
| Navicula, . . . . .                 | 0         | 0          | 0          | 50            | 0          | 0          |
| Synedra, . . . . .                  | 1         | 0          | 220        | 0             | 1          | 200        |
| Tabellaria, . . . . .               | 0         | 0          | 15         | 0             | 0          | 0          |
| <b>Cyanophyceæ, . . . . .</b>       | <b>0</b>  | <b>0</b>   | <b>22</b>  | <b>29,050</b> | <b>8</b>   | <b>8</b>   |
| Anabaena, . . . . .                 | 0         | 0          | 7          | 29,000        | 0          | 0          |
| Clathrocystis, . . . . .            | 0         | 0          | 14         | 50            | 4          | 0          |
| Microcystis, . . . . .              | 0         | 0          | 1          | 0             | 2          | 0          |
| <b>Algæ, . . . . .</b>              | <b>4</b>  | <b>1</b>   | <b>112</b> | <b>5,250</b>  | <b>23</b>  | <b>124</b> |
| Arthrodesmus, . . . . .             | 0         | 0          | 0          | 0             | 0          | 108        |
| Chlorococcus, . . . . .             | 0         | 0          | 0          | 0             | 0          | 3          |
| Protococcus, . . . . .              | 4         | 0          | 67         | 0             | 1          | 0          |
| Raphidium, . . . . .                | 0         | 0          | 10         | 0             | 5          | 5          |
| Scenedesmus, . . . . .              | 0         | 0          | 13         | 50            | 8          | 1          |
| Selenastrum, . . . . .              | 0         | 0          | 0          | 0             | 8          | 5          |
| Staurastrum, . . . . .              | 0         | 0          | 6          | 5,200         | 1          | 0          |
| Tetraspora, . . . . .               | 0         | 0          | 16         | 0             | 0          | 0          |
| Zoospores, . . . . .                | 0         | 1          | 0          | 0             | 0          | 2          |
| <b>Fungi, Crenothrix, . . . . .</b> | <b>0</b>  | <b>3</b>   | <b>1</b>   | <b>0</b>      | <b>0</b>   | <b>0</b>   |
| <b>ANIMALS.</b>                     |           |            |            |               |            |            |
| <b>Infusoria, . . . . .</b>         | <b>30</b> | <b>132</b> | <b>358</b> | <b>150</b>    | <b>138</b> | <b>7</b>   |
| Dinobryon, . . . . .                | 6         | 48         | 0          | 0             | 0          | 0          |
| Dinobryon cases, . . . . .          | 18        | 84         | 352        | 0             | 0          | 7          |
| Monas, . . . . .                    | 0         | 0          | 0          | 50            | 1          | 0          |
| Paramecium, . . . . .               | 0         | 0          | 0          | 100           | 0          | 0          |
| Peridinium, . . . . .               | 6         | 0          | 2          | 0             | 132        | 0          |
| Trachelomonas, . . . . .            | 0         | 0          | 4          | 0             | 3          | 0          |
| <b>Vermes, . . . . .</b>            | <b>1</b>  | <b>1</b>   | <b>10</b>  | <b>0</b>      | <b>6</b>   | <b>1</b>   |
| Anurea, . . . . .                   | 0         | 0          | 4          | 0             | 0          | 1          |
| Polyarthra, . . . . .               | 0         | 1          | 2          | 0             | 0          | 0          |
| Rotatorian ova, . . . . .           | 0         | 0          | 1          | 0             | 0          | 0          |
| Rotifer, . . . . .                  | 1         | 0          | 3          | 0             | 0          | 0          |
| <b>Miscellaneous, . . . . .</b>     | <b>5</b>  | <b>0</b>   | <b>84</b>  | <b>0</b>      | <b>.04</b> | <b>40</b>  |
| Acarina, . . . . .                  | 0         | 0          | 0          | 0             | .04        | 0          |
| Zoöglan, . . . . .                  | 5         | 0          | 84         | 0             | 0          | 40         |
| <b>TOTAL, . . . . .</b>             | <b>41</b> | <b>137</b> | <b>830</b> | <b>34,500</b> | <b>172</b> | <b>372</b> |

## WESTBOROUGH.

*Chemical Examination of Water from the Lower Sandra Reservoir, Westborough.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13683   | 1895. Jan. 16       | Slight.     | Slight.   | .22    | 3.30                    | 1.20              | .0008    | .0186       | .0146      | .0040      | .28       | .0030       | .0000     | .3855            | 0.9       |
| 13979   | Mar. 13             | V. slight.  | Cons.     | .18    | 2.55                    | 0.80              | .0028    | .0114       | .0096      | .0018      | .22       | .0180       | .0000     | .2920            | 0.6       |
| 14296   | May 14              | Slight.     | Slight.   | .12    | 2.70                    | 1.50              | .0004    | .0142       | .0106      | .0036      | .20       | .0030       | .0000     | .2528            | 0.9       |
| 14689   | July 23             | Slight.     | Slight.   | .07    | 2.75                    | 1.30              | .0006    | .0170       | .0118      | .0052      | .27       | .0000       | .0000     | .1612            | 1.3       |
| 15265   | Sept. 24            | Slight.     | Slight.   | .13    | 3.60                    | 1.20              | .0020    | .0154       | .0120      | .0034      | .23       | .0030       | .0000     | .1677            | 1.1       |
| 15622   | Nov. 26             | V. slight.  | Slight.   | .25    | 3.30                    | 1.50              | .0002    | .0240       | .0178      | .0062      | .25       | .0000       | .0000     | .4680            | 0.6       |
| Av.     | 1895                | .....       | .....     | .16    | 3.03                    | 1.25              | .0011    | .0167       | .0127      | .0040      | .24       | .0045       | .0000     | .2879            | 0.9       |
| Av.     | 1894                | .....       | .....     | .07    | 3.15                    | 1.16              | .0009    | .0126       | .0092      | .0034      | .22       | .0018       | .0000     | .1898            | 0.9       |

NOTE to analyses of 1895: Odor, vegetable; sometimes mouldy or unpleasant. On heating, a decided oily odor was developed in January and March.—The samples were collected from the lower reservoir.

*Microscopical Examination of Water from the Lower Sandra Reservoir, Westborough.*

[Number of organisms per cubic centimeter.]

|                               | 1895. |       |       |       |       |       |
|-------------------------------|-------|-------|-------|-------|-------|-------|
|                               | Jan.  | Mar.  | May.  | July. | Sept. | Nov.  |
| Day of examination, . . . . . | 17    | 16    | 15    | 25    | 28    | 27    |
| Number of sample, . . . . .   | 13693 | 13979 | 14296 | 14689 | 15265 | 15622 |
| PLANTS.                       |       |       |       |       |       |       |
| Diatomaceæ, . . . . .         | 2     | 0     | 24    | 29    | 5     | 202   |
| Navicula, . . . . .           | 0     | 0     | 1     | 4     | 0     | 0     |
| Synedra, . . . . .            | 2     | 0     | 13    | 23    | 5     | 192   |
| Tabellaria, . . . . .         | 0     | 0     | 10    | 2     | 0     | 10    |
| Cyanophyceæ, Anabaena, . . .  | 0     | 0     | 10    | 53    | 0     | 0     |
| Algæ, . . . . .               | 0     | 4     | 31    | 17    | 0     | 93    |
| Arthrodesmus, . . . . .       | 0     | 0     | 0     | 0     | 0     | 58    |
| Prorococcus, . . . . .        | 0     | 0     | 20    | 16    | 0     | 0     |
| Raphidium, . . . . .          | 0     | 0     | 4     | 0     | 0     | 4     |
| Staurastrum, . . . . .        | 0     | 0     | 7     | 1     | 0     | 1     |
| Zoopores, . . . . .           | 0     | 4     | 0     | 0     | 0     | 0     |
| Fungi, Crenothrix, . . . . .  | 1     | 1     | 0     | 2     | 0     | 0     |

## WESTBOROUGH.

*Microscopical Examination of Water from the Lower Sandra Reservoir, Westborough—Concluded.*

[Number of organisms per cubic centimeter.]

|                                        | 1895. |      |      |       |       |      |
|----------------------------------------|-------|------|------|-------|-------|------|
|                                        | Jan.  | Mar. | May. | July. | Sept. | Nov. |
| <b>ANIMALS.</b>                        |       |      |      |       |       |      |
| <b>Rhizopoda, Arcella, . . . .</b>     | 0     | 0    | 0    | 0     | 0     | 1    |
| <b>Infusoria, . . . . .</b>            | 75    | 71   | 21   | 401   | 1     | 17   |
| Dinobryon, . . . . .                   | 18    | 42   | 2    | 0     | 0     | 0    |
| Dinobryon cases, . . . . .             | 40    | 0    | 15   | 328   | 0     | 3    |
| Euglena, . . . . .                     | 1     | 3    | 0    | 0     | 0     | 1    |
| Peridinium, . . . . .                  | 18    | 2    | 3    | 72    | 0     | 12   |
| Synura, . . . . .                      | 0     | 0    | 1    | 0     | 0     | 0    |
| Tintinnidium, . . . . .                | 0     | 0    | 0    | 0     | 0     | 1    |
| Trachelomonas, . . . . .               | 0     | 24   | 0    | 1     | 1     | 0    |
| <b>Vermes, . . . . .</b>               | 0     | 1    | 15   | 7     | 1     | 1    |
| Anura, . . . . .                       | 0     | 0    | 11   | 7     | 0     | 1    |
| Polvarthra, . . . . .                  | 0     | 1    | 4    | 0     | 0     | 0    |
| Rotifer, . . . . .                     | 0     | 0    | 0    | 0     | 1     | 0    |
| <b>Miscellaneous, Zoöglæa, . . . .</b> | 0     | 0    | 0    | 0     | 0     | 7    |
| <b>TOTAL, . . . . .</b>                | 78    | 77   | 101  | 509   | 7     | 321  |

## WATER SUPPLY OF WESTBOROUGH INSANE HOSPITAL, WESTBOROUGH.

*Chemical Examination of Water from the Tubular Wells at the Westborough Insane Hospital.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |            |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|------------------|------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.       | Sediment.  | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
|         |                     |                  |            |        |                         |          |             |           |             |           |                  |           |       |
| 1893.   |                     |                  |            |        |                         |          |             |           |             |           |                  |           |       |
| 13900   | Feb. 27             | Distinct, milky. | V. slight. | .55    | 11.90                   | .1440    | .0040       | .40       | .0050       | .0000     | .1540            | 6.4       | .2200 |
| 14349   | May 22              | Slight, milky.   | V. slight. | .50    | 12.69                   | .1160    | .0000       | .40       | .0000       | .0000     | .1087            | 5.9       | .1520 |
| 14924   | Aug. 27             | Distinct, milky. | V. slight. | .60    | 12.00                   | .0992    | .0032       | .40       | .0000       | .0002     | .1092            | 5.3       | .0700 |
| Av.     | .....               | .....            | .....      | .55    | 12.17                   | .1197    | .0024       | .40       | .0017       | .0001     | .1240            | 5.9       | .1473 |

*Averages by Years.*

|   |       |   |   |     |       |       |       |     |       |       |       |     |       |
|---|-------|---|---|-----|-------|-------|-------|-----|-------|-------|-------|-----|-------|
| - | 1887* | - | - | .03 | 11.29 | .0407 | .0033 | .42 | .0030 | -     | -     | -   | -     |
| - | 1888  | - | - | .06 | 11.27 | .0502 | .0051 | .42 | .0045 | .0000 | -     | -   | -     |
| - | 1889† | - | - | .16 | 11.41 | .0530 | .0049 | .43 | .0030 | .0000 | -     | -   | -     |
| - | 1891‡ | - | - | .50 | 11.80 | .0781 | .0109 | .43 | .0040 | .0000 | -     | 6.0 | -     |
| - | 1893§ | - | - | .33 | 11.09 | .0758 | .0056 | .40 | .0078 | .0001 | .1200 | 5.8 | .0964 |
| - | 1894  | - | - | .39 | 11.75 | .1188 | .0082 | .37 | .0007 | .0000 | .1466 | 6.1 | .1687 |
| - | 1895  | - | - | .55 | 12.17 | .1197 | .0024 | .40 | .0017 | .0001 | .1240 | 5.9 | .1473 |

\* June to December.

† January to May.

‡ July, two samples.

§ January, March, May and July.

|| February, May and August.

NOTE to analyses of 1895: Odor, none when cold. On heating, a distinctly unpleasant odor was developed in the last sample. — The samples were collected from a faucet at the pumping station.

*Microscopical Examination.*

An insignificant number of organisms was found in each of these samples.



**WESTBOROUGH.**

A communication from the selectmen of Northborough to the State Board of Health relative to the pollution of Little Chauncy Pond by the sewage of the Westborough Insane Hospital, and the advice of the State Board of Health to the trustees of the Westborough Insane Hospital relative to the disposal of the sewage from this institution may be found on pages 70 and 71 of this volume.

Analyses of samples of water from Chauncy and Little Chauncy ponds are given below.

*Chemical Examination of Water from Chauncy Pond, Westborough.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 15627   | 1895.<br>Nov. 26    | None.       | V. slight. | .47    | 4.65                    | 2.65              | .0028    | .0262       | .0254      | .0008      | .39       | .0050       | .0001     | .7379            | 1.6       |

Odor, faintly vegetable; on heating, distinctly mouldy. — The sample was collected from a faucet on the pump drawing water from Chauncy Pond.

*Microscopical Examination.*

An insignificant number of organisms was found in this sample.

*Chemical Examination of Water from Chauncy and Little Chauncy Ponds, Westborough.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.     |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-----------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.      | Sediment.       | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                 |                 |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 15503   | 1895.<br>Nov. 10    | Decided, green. | Slight, yellow. | .32    | 4.90                    | 2.15              | .0042    | .0564       | .0330      | .0234      | .45       | .0030       | .0001     | .6880            | 1.3       |
| 15502   | Nov. 10             | Decided, green. | Slight, yellow. | .47    | 5.80                    | 2.40              | .0022    | .0666       | .0444      | .0222      | .51       | .0050       | .0002     | .8408            | 1.7       |

Odor of the first sample, faintly vegetable, becoming stronger on heating; of the second sample, distinctly disagreeable. — The first sample was collected from Chauncy Pond at its outlet, and the second from Little Chauncy Pond at its outlet. The samples were collected during an investigation relative to the alleged pollution of Little Chauncy Pond by sewage from the Westborough Insane Hospital.

*Microscopical Examination.*

No. 15503. Diatomaceæ, *Asterionella*, 4; *Cyclotella*, 30; *Fragilaria*, 292; *Melosira*, 8; *Synedra*, 66; *Tabellaria*, 16. Cyanophyceæ, *Anabæna*, 160; *Chroococcus*, 2; *Clathrocystis*, 40; *Celosphaerium*, 2; *Microcystis*, 40. Algæ, *Chlorococcus*, 18; *Raphidium*, 20; *Scenedesmus*, 2; *Staurastrum*, 4; *Zoospores*, 6. Fungi, *Beggiatoa*, 2. Infusoria, *Monas*, 2. Vermes, *Anurea*, 2. Crustacea, *Daphnia*, .02. Miscellaneous, *Acarina*, .02; *Zoëglæa*, 60. Total, 1376.

No. 15502. Diatomaceæ, *Fragilaria*, 60; *Melosira*, 174; *Meridion*, 1; *Stauroneta*, 2; *Synedra*, 10. Cyanophyceæ, *Anabæna*, 960; *Clathrocystis*, 1; *Microcystis*, 2; *Ocellularia*, 2. Algæ, *Chlorococcus*, 2; *Cosmarium*, 1; *Protococcus*, 15; *Raphidium*, 2; *Scenedesmus*, 2; *Staurastrum*, 9; *Zoospores*, 168. Fungi, *Crenothrix*, 13. Infusoria, *Dinobryon*, 3; *Peridinium*, 3; *Synura*, 21; *Euglena*, 52. Vermes, *Anurea*, 2; *Rotifer*, 1. Crustacea, *Cyclops*, .02; *Daphnia*, .06. Miscellaneous, *Acarina*, .04; *Zoëglæa*, 5. Total, 1511.

## WESTFIELD.

## WATER SUPPLY OF WESTFIELD.

The advice of the State Board of Health to the town of Westfield relative to taking the water of Munn Brook in Granville as an additional water supply for Westfield may be found on page 52 of this volume.

*Chemical Examination of Water from the Westfield Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.       | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                 |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.   |                     |             |                 |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 14916   | Aug. 25             | Distinct.   | Cons.           | .60    | 2.85                    | 1.60              | .0046    | .0234       | .0202      | .0032      | .11       | .0000       | .0000     | .7254            | 0.1       |
| 14917   | Aug. 25             | Slight.     | Slight, yellow. | .70    | 3.15                    | 1.50              | .0028    | .0160       | .0126      | .0034      | .14       | .0100       | .0001     | .6630            | 0.3       |
| 14918   | Aug. 27             | Slight.     | Slight.         | .88    | 3.35                    | 1.50              | .0012    | .0172       | .0150      | .0022      | .10       | .0120       | .0002     | .6162            | 1.1       |

Odor of the first sample, distinctly vegetable and unpleasant; of the second, distinctly vegetable; of the last, faintly vegetable. — The first sample was collected from the storage reservoir at its centre; the second, from the distributing reservoir near the gate-house; and the last, from a faucet in the town.

*Microscopical Examination of Water from the Westfield Water Works.*

[Number of organisms per cubic centimeter.]

|                               | 1895. |       |       |
|-------------------------------|-------|-------|-------|
|                               | Aug.  | Aug.  | Aug.  |
| Day of examination, . . . . . | 29    | 29    | 29    |
| Number of sample, . . . . .   | 14916 | 14917 | 14918 |
| <b>PLANTS.</b>                |       |       |       |
| Diatomaceæ, . . . . .         | 132   | 1     | 4     |
| Asterionella, . . . . .       | 44    | 0     | 3     |
| Cyclotella, . . . . .         | 0     | 1     | 0     |
| Fragilaria, . . . . .         | 2     | 0     | 0     |
| Tabellaria, . . . . .         | 86    | 0     | 1     |
| Cyanophyceæ, . . . . .        | 27    | 0     | 0     |
| Anabæna, . . . . .            | 26    | 0     | 0     |
| Microcystis, . . . . .        | 1     | 0     | 0     |
| Algæ, . . . . .               | 4     | 2     | 2     |
| Protozoæna, . . . . .         | 0     | 2     | 0     |
| Raphidium, . . . . .          | 4     | 0     | 0     |
| Scenedesmus, . . . . .        | 0     | 0     | 1     |
| Staurostrum, . . . . .        | 0     | 0     | 1     |
| Fungi, . . . . .              | 0     | 18    | 3     |
| Crenothrix, . . . . .         | 0     | 17    | 3     |
| Molds, . . . . .              | 0     | 1     | 0     |

## WESTFIELD.

*Microscopical Examination of Water from the Westfield Water Works — Concluded.*

[Number of organisms per cubic centimeter.]

|                               |  | 1895. |      |      |
|-------------------------------|--|-------|------|------|
|                               |  | Aug.  | Aug. | Aug. |
| <b>ANIMALS.</b>               |  |       |      |      |
| Infusoria, . . . . .          |  | 16    | 1    | 2    |
| Dinobryon cases, . . . . .    |  | 11    | 0    | 0    |
| Peridinium, . . . . .         |  | 3     | 0    | 1    |
| Tintinnidium, . . . . .       |  | 1     | 0    | 0    |
| Trachelomonas, . . . . .      |  | 1     | 1    | 0    |
| Vorticella, . . . . .         |  | 0     | 0    | 1    |
| Vermes, Anura, . . . . .      |  | 1     | 0    | 0    |
| Crustacea, Bosmina, . . . . . |  | .10   | 0    | 0    |
| Miscellaneous, . . . . .      |  | 880   | 580  | 0    |
| Acarina, . . . . .            |  | .08   | 0    | 0    |
| Zoöglæa, . . . . .            |  | 880   | 580  | 0    |
| TOTAL, . . . . .              |  | 1,000 | 602  | 11   |

## WESTON.

The advice of the State Board of Health to the petitioners for incorporation as the Weston Water and Electric Company relative to taking a water supply for the town of Weston from springs in that town may be found on pages 52 and 53 of this volume. The results of analyses of samples of water collected from tubular wells near the source of Cherry Brook and from tubular wells near Central Avenue are given in the following table.

*Chemical Examination of Water from Tubular Test Wells in Weston.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |                 |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------------|-----------------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.        | Sediment.       | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 14237   | 1895.<br>May 2      | Slight, clayey.   | Slight, clayey. | .04    | 8.90                    | .0012    | .0020       | .70       | .2060       | .0002     | .0962            | 3.2       | .0100 |
| 14574   | July 1              | Distinct, clayey. | Cons., earthy.  | .00    | 5.00                    | .0000    | .0002       | .44       | .0500       | .0000     | .0395            | 1.9       | .0120 |

Odor of the first sample, none. The second sample had an odor of machine oil. — The first sample was collected from a driven well near the upper source of Cherry Brook, and the second from a driven well in a meadow north of Central Avenue.

*Microscopical Examination.*No. 14237. Fungi, *Crenothrix*, 1. Miscellaneous, *Zoöglæa*, 68. Total, 69.

No. 14574. No organisms.

## WEST SPRINGFIELD.

## WATER SUPPLY OF WEST SPRINGFIELD.

In the spring of 1895 the works for supplying West Springfield with water were enlarged by the construction of a pipe line to divert the water from springs in the valley of Block Brook into the brook supplying West Springfield Reservoir.

The water of the springs is collected in a small wooden collecting well located on the easterly side of Block Brook, about three-quarters of a mile above the point where it is crossed by the Westfield road. The water flows by gravity from the well to the brook which supplies the West Springfield Reservoir.

## WATER SUPPLY OF WEYMOUTH.

*Chemical Examination of Water from Great Pond, in Weymouth.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.       | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |             |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                 |        |                         |                   |          | Total.      | Dissolved. | Sus-pended. |           |             |           |                  |           |
| 14046   | 1895.<br>Mar. 27    | V. slight.  | V. slight.      | 0.90   | 4.05                    | 1.80              | .0004    | .0198       | .0186      | .0012       | .58       | .0030       | .0000     | 0.8470           | 1.3       |
| 14532   | June 24             | Distinct.   | Slight, yellow. | 0.73   | 4.00                    | 1.80              | .0014    | .0218       | .0200      | .0018       | .60       | .0030       | .0000     | 0.7815           | 0.5       |
| 15275   | Sept. 26            | V. slight.  | Slight, brown.  | 0.40   | 3.70                    | 1.75              | .0000    | .0156       | .0146      | .0010       | .59       | .0070       | .0000     | 0.4758           | 0.3       |
| 15788   | Dec. 23             | V. slight.  | V. slight       | 1.25   | 4.55                    | 2.60              | .0002    | .0214       | .0202      | .0012       | .46       | .0030       | .0000     | 1.0780           | 0.5       |
| Av.     | .....               | .....       | .....           | 0.82   | 4.07                    | 1.99              | .0005    | .0196       | .0183      | .0013       | .56       | .0040       | .0000     | 0.7956           | 0.6       |

*Averages by Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | 0.93 | 4.08 | 1.75 | .0007 | .0219 | -     | -     | .47 | .0030 | -     | -     | -   |
| - | 1888† | - | - | 0.88 | 4.15 | 1.94 | .0020 | .0225 | -     | -     | .48 | .0074 | .0000 | -     | -   |
| - | 1889‡ | - | - | 1.40 | -    | -    | .0000 | .0230 | .0220 | .0010 | -   | .0040 | .0000 | -     | -   |
| - | 1892  | - | - | 0.94 | 3.82 | 1.86 | .0000 | .0173 | .0156 | .0017 | .51 | .0077 | .0000 | -     | 0.4 |
| - | 1893  | - | - | 0.76 | 3.86 | 1.66 | .0003 | .0163 | .0139 | .0025 | .57 | .0008 | .0000 | .6847 | 0.5 |
| - | 1894  | - | - | 0.77 | 3.99 | 1.80 | .0003 | .0169 | .0156 | .0013 | .61 | .0015 | .0000 | .6703 | 0.7 |
| - | 1895  | - | - | 0.82 | 4.07 | 1.99 | .0005 | .0196 | .0183 | .0013 | .56 | .0040 | .0000 | .7956 | 0.6 |

\* June to December.

† January to May.

‡ July.

NOTE to analyses of 1895: Odor of the third sample, none; of the others, distinctly vegetable. — The samples were collected from faucets in the town.

## WEYMOUTH.

*Microscopical Examination of Water from Great Pond, in Weymouth.*

[Number of organisms per cubic centimeter.]

|                               | 1895. |       |       |       |
|-------------------------------|-------|-------|-------|-------|
|                               | Mar.  | July. | Oct.  | Dec.  |
| Day of examination, . . . . . | 29    | 26    | 1     | 24    |
| Number of sample, . . . . .   | 14046 | 14532 | 15275 | 15788 |
| <b>PLANTS.</b>                |       |       |       |       |
| Diatomaceæ, . . . . .         | 103   | 122   | 0     | 0     |
| Asterionella, . . . . .       | 96    | 120   | 0     | 0     |
| Synedra, . . . . .            | 0     | 2     | 0     | 0     |
| Tabellaria, . . . . .         | 7     | 0     | 0     | 0     |
| Algae, . . . . .              | 0     | 12    | 0     | 2     |
| Protococcus, . . . . .        | 0     | 12    | 0     | 0     |
| Zoopores, . . . . .           | 0     | 0     | 0     | 2     |
| Fungi, Crenothrix, . . . . .  | 0     | 34    | 60    | 0     |
| <b>ANIMALS.</b>               |       |       |       |       |
| Infusoria, . . . . .          | 136   | 1,880 | 0     | 0     |
| Dinobryon, . . . . .          | 2     | 1,860 | 0     | 0     |
| Dinobryon cases, . . . . .    | 136   | 620   | 0     | 0     |
| TOTAL, . . . . .              | 241   | 2,648 | 60    | 2     |

## WATER SUPPLY OF WILLIAMSTOWN. — WILLIAMSTOWN WATER COMPANY.

The advice of the State Board of Health to the Williamstown Water Company, relative to taking the water of Flora Glen Brook as a source of additional water supply for the town, may be found on page 53 of this volume.

*Chemical Examination of Water from Cold Spring Reservoir and from Sherman Spring, Williamstown.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|------------------|-----------|-------------|-----------|-----------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                 |           |       |
|         | 1895.               |             |           |        |                         |          |                  |           |             |           |                 |           |       |
| 14904   | Aug. 23             | Slight.     | Slight.   | .02    | 13.70                   | .0000    | .0000            | .10       | .0480       | .0000     | .0234           | 11.9      | .0040 |
| 14905   | Aug. 23             | None.       | None.     | .00    | 9.90                    | .0000    | .0000            | .10       | .0150       | .0000     | .0000           | 7.9       | .0030 |

Odor, none. — The first sample was collected from Cold Spring Reservoir, and the second from Sherman Spring.

*Microscopical Examination.*

No. 14904. No organisms.

No. 14905. Diatomaceæ, *Mertidion*, 7.

## WILLIAMSTOWN.

*Chemical Examination of Water from Flora Glen Brook, Williamstown.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |            |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 15271   | 1895.<br>Sept. 27   | V. slight.  | V. slight. | .00    | 6.55                            | 0.35                 | .0000    | .0020       | .0010      | .0010           | .08       | .0030          | .0000     | .0819            | 4.        |

Odor, none. — The sample was collected from the brook, above the site of a proposed reservoir.

*Microscopical Examination.*

Fungi, Molds, 2.

## WINCHENDON.

The advice of the State Board of Health to the town of Winchendon with regard to the use of water from the ground in Prentiss Meadow as a source of water supply for the town may be found on pages 54 to 57 of this volume.

## WATER SUPPLY OF WINCHESTER.

During the last two years there has been a marked increase in the amount of chlorine present in the water of North Reservoir, which is shown in the table of averages by years of chemical examinations of water from this source, given below. This increase is probably due to the increase in population upon the portion of the watershed of the reservoir within the village of Stoneham. It was found by examination, in 1895, that this portion of the watershed contained 400 people.

## WINCHESTER.

*Chemical Examination of Water from the North Reservoir of the Winchester Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                     |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 13586   | 1895.<br>Jan. 2     | V. slight.          | V. slight.        | .07    | 7.00                            | 1.90                 | .0040    | .0226       | .0208      | .0018           | 1.04      | .0150          | .0001     | .2656            | 3.0       |
| 13764   | Feb. 5              | V. slight.          | Slight.           | .12    | 5.40                            | 1.85                 | .0084    | .0136       | .0122      | .0014           | 0.78      | .0200          | .0000     | .2473            | 2.1       |
| 13922   | Mar. 5              | V. slight.          | Cons.             | .10    | 7.00                            | 2.15                 | .0092    | .0168       | .0140      | .0018           | 1.03      | .0350          | .0007     | .3118            | 2.7       |
| 14081   | Apr. 2              | Slight.             | V. slight.        | .05    | 5.90                            | 1.80                 | .0010    | .0166       | .0140      | .0026           | 0.79      | .0300          | .0001     | .1963            | 2.3       |
| 14246   | May 6               | Distinct.           | Cons.             | .12    | 6.50                            | 2.25                 | .0006    | .0170       | .0142      | .0028           | 0.80      | .0280          | .0002     | .2502            | 2.7       |
| 14411   | June 4              | Slight.             | Slight.           | .08    | 6.25                            | 2.35                 | .0002    | .0188       | .0162      | .0026           | 0.89      | .0190          | .0003     | .2698            | 2.5       |
| 14589   | July 9              | Distinct.           | Slight.           | .10    | 5.95                            | 1.85                 | .0012    | .0238       | .0188      | .0050           | 0.88      | .0130          | .0001     | .3081            | 2.5       |
| 14772   | Aug. 6              | Distinct.           | Slight.           | .10    | 6.80                            | 2.20                 | .0006    | .0240       | .0188      | .0052           | 0.90      | .0120          | .0000     | .3354            | 2.9       |
| 14958   | Sept. 3             | Distinct.           | Slight,<br>brown. | .10    | 7.20                            | 2.25                 | .0000    | .0198       | .0168      | .0030           | 0.93      | .0000          | .0001     | .2911            | 2.6       |
| 15293   | Oct. 2              | Distinct.           | Cons.,<br>brown.  | .10    | 6.90                            | 2.00                 | .0006    | .0220       | .0190      | .0030           | 0.93      | .0000          | .0000     | .2792            | 2.5       |
| 15476   | Nov. 5              | Distinct.           | Slight,<br>green. | .15    | 6.75                            | 2.10                 | .0020    | .0248       | .0202      | .0046           | 0.91      | .0280          | .0001     | .3822            | 2.7       |
| 15660   | Dec. 3              | Distinct,<br>green. | Cons.,<br>yellow. | .20    | 6.35                            | 2.45                 | .0010    | .0254       | .0184      | .0070           | 0.90      | .0200          | .0002     | .3572            | 2.6       |
| Av.     | .....               | .....               | .....             | .11    | 6.50                            | 2.05                 | .0024    | .0203       | .0169      | .0034           | 0.91      | .0183          | .0002     | .2912            | 2.6       |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | .11 | 5.08 | 1.18 | .0015 | .0196 | -     | -     | .53 | .0037 | -     | -     | -   |
| - | 1888  | - | - | .15 | 4.93 | 1.24 | .0045 | .0273 | -     | -     | .47 | .0131 | .0003 | -     | -   |
| - | 1889  | - | - | .13 | 4.52 | 1.18 | .0022 | .0223 | .0176 | .0047 | .47 | .0165 | .0003 | -     | -   |
| - | 1890  | - | - | .09 | 5.30 | 1.31 | .0017 | .0201 | .0160 | .0041 | .52 | .0153 | .0002 | -     | 2.7 |
| - | 1891  | - | - | .10 | 4.94 | 1.39 | .0034 | .0222 | .0169 | .0053 | .51 | .0152 | .0001 | -     | 2.1 |
| - | 1892  | - | - | .06 | 5.23 | 1.59 | .0058 | .0217 | .0177 | .0040 | .60 | .0192 | .0002 | -     | 2.5 |
| - | 1893  | - | - | .07 | 5.13 | 1.62 | .0055 | .0252 | .0172 | .0080 | .59 | .0127 | .0002 | .2718 | 2.3 |
| - | 1894  | - | - | .09 | 5.85 | 1.86 | .0017 | .0198 | .0160 | .0038 | .82 | .0076 | .0001 | .2491 | 2.5 |
| - | 1895  | - | - | .11 | 6.50 | 2.05 | .0024 | .0203 | .0169 | .0034 | .91 | .0183 | .0002 | .2912 | 2.6 |

\* June to December.

NOTE to analyses of 1895: Odor, in January, none; at other times, vegetable; stronger during the latter half of the year than during the first half. — The samples were collected from the reservoir.

## WINCHESTER.

*Microscopical Examination of Water from the North Reservoir of the Winchester Water Works.*

[Number of organisms per cubic centimeter.]

|                                 | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|---------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                 | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June  | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . .     | 4     | 6     | 7     | 3     | 7     | 5     | 10    | 8     | 5     | 3     | 6     | 4     |
| Number of sample, . . . .       | 13586 | 13764 | 13922 | 14081 | 14246 | 14411 | 14589 | 14772 | 14958 | 15298 | 15476 | 15660 |
| PLANTS.                         |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . .             | 0     | 0     | pr.   | 1     | 560   | 123   | 18    | 101   | 38    | 318   | 3,369 | 4,973 |
| Asterionella, . . . .           | 0     | 0     | 0     | 0     | 232   | 22    | 16    | 88    | 28    | 160   | 3,328 | 4,960 |
| Cyclotella, . . . .             | 0     | 0     | pr.   | 0     | 52    | 74    | 0     | 0     | 3     | 8     | 1     | 3     |
| Cymbella, . . . .               | 0     | 0     | 0     | 0     | 3     | 0     | 2     | 0     | 1     | 0     | 0     | 0     |
| Fragilaria, . . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 40    | 0     |
| Melosira, . . . .               | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 9     | 0     | 142   | 0     | 0     |
| Navicula, . . . .               | 0     | 0     | 0     | 0     | 8     | 1     | 0     | 2     | 1     | 4     | 0     | 0     |
| Synedra, . . . .                | 0     | 0     | 0     | 1     | 236   | 10    | 0     | 1     | 5     | 4     | 0     | 0     |
| Tabellaria, . . . .             | 0     | 0     | 0     | 0     | 31    | 13    | 0     | 1     | 0     | 0     | 0     | 10    |
| Cyanophyceæ, . . . .            | 0     | 1     | 0     | 0     | 0     | 0     | 366   | 122   | 4     | 8     | 62    | 8     |
| Anabaena, . . . .               | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 78    | 0     | 2     | 0     | 0     |
| Clostrorhynchus, . . . .        | 0     | 0     | 0     | 0     | 0     | 0     | 360   | 44    | 0     | 0     | 1     | 0     |
| Coelosphaerium, . . . .         | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     |
| Microcystis, . . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 6     | 7     | 8     |
| Nostoc, . . . .                 | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 53    | 0     |
| Algae, . . . .                  | 0     | 0     | pr.   | 2     | 32    | 39    | 126   | 12    | 59    | 74    | 16    | 23    |
| Chlorococcos, . . . .           | 0     | 0     | 0     | 0     | 0     | 29    | 0     | 0     | 0     | 4     | 2     | 0     |
| Closterium, . . . .             | 0     | 0     | 0     | 2     | 23    | 2     | 0     | 0     | 1     | 0     | 0     | 0     |
| Cocci, . . . .                  | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 7     |
| Protoecoccus, . . . .           | 0     | 0     | pr.   | 0     | 0     | 7     | 126   | 0     | 0     | 0     | 0     | 0     |
| Raphidium, . . . .              | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 12    | 56    | 68    | 13    | 16    |
| Scenedesmus, . . . .            | 0     | 0     | 0     | 0     | 8     | 1     | 0     | 0     | 2     | 2     | 0     | 0     |
| Fungi, Crenothrix, . . . .      | 0     | 0     | pr.   | 0     | 1     | 0     | 0     | 0     | 1     | 0     | 5     | 0     |
| ANIMALS.                        |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . . .              | 2     | 3     | pr.   | 717   | 156   | 181   | 0     | 7     | 8     | 116   | 2     | 4     |
| Ciliated Infusorian, . . . .    | 0     | 0     | 0     | 50    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon, . . . .              | 0     | 0     | 0     | 600   | 0     | 17    | 0     | 0     | 0     | 22    | 0     | 0     |
| Dinobryon cases, . . . .        | 0     | 0     | 0     | 0     | 156   | 149   | 0     | 0     | 0     | 72    | 1     | 0     |
| Mallomonas, . . . .             | 0     | 0     | 0     | 0     | 0     | 15    | 0     | 0     | 0     | 4     | 0     | 1     |
| Monas, . . . .                  | 0     | 0     | 0     | 50    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Peridinium, . . . .             | 1     | 3     | pr.   | 17    | 0     | 0     | 0     | 6     | 7     | 0     | 0     | 0     |
| Trachelomonas, . . . .          | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 1     | 18    | 1     | 3     |
| Vermes, Anurea, . . . .         | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 1     | 0     | 0     | 0     | 0     |
| Crustacea, Cyclops, . . . .     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | .12   |
| Miscellaneous, Zoöglon, . . . . | 0     | 0     | 6     | 0     | 68    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| TOTAL, . . . .                  | 2     | 4     | 6     | 720   | 818   | 343   | 610   | 243   | 110   | 516   | 3,454 | 5,008 |



## WINCHESTER.

*Chemical Examination of Water from the South Reservoir of the Winchester Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.     |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-----------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.      | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                 |                |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13588   | 1895.<br>Jan. 2     | V. slight.      | Slight.        | .43    | 5.70                    | 1.95              | .0142    | .0306       | .0266      | .0040      | .52       | .0040       | .0001     | .5837            | 2.6       |
| 13766   | Feb. 5              | Slight.         | Slight.        | .45    | 4.80                    | 1.35              | .0088    | .0202       | .0188      | .0014      | .43       | .0070       | .0000     | .3105            | 2.1       |
| 13924   | Mar. 5              | V. slight.      | V. slight.     | .10    | 3.85                    | 1.40              | .0150    | .0206       | .0198      | .0008      | .43       | .0070       | .0000     | .4004            | 1.8       |
| 14083   | Apr. 2              | V. slight.      | V. slight.     | .07    | 3.85                    | 1.30              | .0014    | .0202       | .0186      | .0016      | .30       | .0080       | .0000     | .2964            | 1.3       |
| 14247   | May 6               | Slight.         | Cons.          | .20    | 4.30                    | 2.15              | .0014    | .0268       | .0248      | .0020      | .38       | .0080       | .0001     | .4196            | 1.9       |
| 14413   | June 4              | Distinct.       | Slight.        | .10    | 4.00                    | 1.85              | .0008    | .0294       | .0232      | .0062      | .40       | .0050       | .0000     | .4256            | 1.7       |
| 14591   | July 9              | Slight.         | Slight.        | .12    | 4.30                    | 1.85              | .0004    | .0266       | .0238      | .0028      | .40       | .0070       | .0000     | .4187            | 1.7       |
| 14774   | Aug. 6              | Slight.         | Slight.        | .12    | 4.45                    | 1.65              | .0006    | .0290       | .0246      | .0044      | .43       | .0080       | .0000     | .4368            | 2.1       |
| 14959   | Sept. 3             | Distinct.       | Slight.        | .13    | 5.15                    | 2.05              | .0000    | .0296       | .0224      | .0042      | .44       | .0000       | .0003     | .4297            | 1.7       |
| 15300   | Oct. 2              | Slight.         | Slight.        | .12    | 4.40                    | 2.00              | .0000    | .0258       | .0220      | .0038      | .44       | .0030       | .0000     | .4118            | 1.7       |
| 15477   | Nov. 5              | Decided, green. | Slight, green. | .20    | 4.25                    | 1.75              | .0046    | .0288       | .0242      | .0046      | .42       | .0250       | .0001     | .4017            | 2.1       |
| 15662   | Dec. 3              | Slight.         | Slight.        | .17    | 4.20                    | 1.90              | .0000    | .0284       | .0224      | .0060      | .36       | .0020       | .0000     | .3900            | 1.7       |
| Av.     | .....               | .....           | .....          | .18    | 4.44                    | 1.77              | .0039    | .0261       | .0226      | .0035      | .41       | .0070       | .0001     | .4104            | 1.9       |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1891* | - | - | .60 | 5.73 | 2.09 | .0110 | .0486 | .0361 | .0125 | .40 | .0094 | .0006 | -     | 2.3 |
| - | 1892  | - | - | .51 | 5.17 | 2.04 | .0055 | .0392 | .0318 | .0074 | .38 | .0118 | .0002 | -     | 2.2 |
| - | 1893  | - | - | .34 | 4.78 | 1.86 | .0064 | .0291 | .0216 | .0075 | .36 | .0093 | .0002 | .4891 | 2.1 |
| - | 1894  | - | - | .18 | 4.56 | 1.76 | .0049 | .0267 | .0232 | .0035 | .41 | .0024 | .0001 | .4452 | 1.9 |
| - | 1895  | - | - | .18 | 4.44 | 1.77 | .0039 | .0261 | .0226 | .0035 | .41 | .0070 | .0001 | .4104 | 1.9 |

\* August to December.

NOTE to analyses of 1895: Odor, until September, faintly vegetable; in September, distinctly vegetable; in October, unpleasant; in November and December, distinctly disagreeable. — The samples were collected from the reservoir, near the gate-house.

## WINCHESTER.

*Microscopical Examination of Water from the South Reservoir of the Winchester Water Works.*

[Number of organisms per cubic centimeter.]

|                                  | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                  | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .        | 4     | 6     | 7     | 3     | 7     | 5     | 10    | 8     | 5     | 6     | 3     | 4     |
| Number of sample, . . .          | 13585 | 13766 | 13924 | 14083 | 14247 | 14413 | 14591 | 14774 | 14950 | 15300 | 15477 | 15662 |
| PLANTS.                          |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . .              | 0     | 2     | 0     | 6     | 875   | 1,021 | 0     | 7     | 51    | 432   | 236   | 519   |
| Asterionella, . . . .            | 0     | 0     | 0     | 0     | 49    | 13    | 0     | 0     | 14    | 432   | 236   | 512   |
| Cyclotella, . . . .              | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 36    | 0     | 0     | 0     |
| Navicula, . . . .                | 0     | 1     | 0     | 0     | 2     | 2     | 0     | 3     | 0     | 0     | 0     | 0     |
| Synedra, . . . .                 | 0     | 1     | 0     | 0     | 192   | 2     | 0     | 3     | 1     | 0     | 0     | 4     |
| Tabellaria, . . . .              | 0     | 0     | 0     | 6     | 632   | 1,004 | 0     | 1     | 0     | 0     | 0     | 3     |
| Cyanophyceæ, . . . .             | 0     | 1     | 2     | 0     | 0     | 0     | 44    | 4     | 46    | 1     | 4     | 0     |
| Anabaena, . . . .                | 0     | 0     | 0     | 0     | 0     | 0     | 5     | 4     | 46    | 1     | 0     | 0     |
| Celosphaerium, . . . .           | 0     | 1     | 2     | 0     | 0     | 0     | 3     | 0     | 0     | 0     | 2     | 0     |
| Microcystis, . . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 36    | 0     | 0     | 0     | 2     | 0     |
| Algae, . . . .                   | 0     | 0     | 0     | 6     | 134   | 616   | 317   | 32    | 6     | 99    | 276   | 355   |
| Closterium, . . . .              | 0     | 0     | 0     | 0     | 128   | 612   | 0     | 0     | 0     | 0     | 0     | 0     |
| Protooccus, . . . .              | 0     | 0     | 0     | 4     | 1     | 4     | 296   | 30    | 0     | 11    | 0     | 0     |
| Raphidium, . . . .               | 0     | 0     | 0     | 0     | 0     | 0     | 20    | 2     | 6     | 88    | 0     | 24    |
| Scenedesmus, . . . .             | 0     | 0     | 0     | 0     | 4     | 0     | 1     | 0     | 0     | 0     | 0     | 11    |
| Zoisporos, . . . .               | 0     | 0     | 0     | 2     | 1     | 0     | 0     | 0     | 0     | 0     | 276   | 320   |
| ANIMALS.                         |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . . .               | 21    | 22    | 1     | 2     | 315   | 10    | 69    | 52    | 2     | 5     | 0     | 4     |
| Ceratium, . . . .                | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 1     | 0     | 0     |
| Dinobryon, . . . .               | 0     | 0     | 0     | 0     | 78    | 0     | 68    | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, . . . .         | 0     | 20    | 0     | 0     | 200   | 0     | 0     | 32    | 0     | 0     | 0     | 0     |
| Mallomonas, . . . .              | 7     | 0     | 0     | 0     | 2     | 0     | 0     | 4     | 0     | 0     | 0     | 4     |
| Peridinium, . . . .              | 13    | 0     | 0     | 0     | 0     | 0     | 0     | 11    | 1     | 0     | 0     | 0     |
| Trachelomonas, . . . .           | 1     | 2     | 1     | 2     | 36    | 10    | 1     | 5     | 0     | 0     | 0     | 0     |
| Vorticella, . . . .              | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 0     | 0     |
| Vermes, . . . .                  | 0     | 1     | 1     | 0     | 6     | 0     | 0     | 0     | 0     | 0     | 2     | 0     |
| Anura, . . . .                   | 0     | 1     | 1     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Rotarian ova, . . . .            | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 1     | 0     |
| Rotifer, . . . .                 | 0     | 0     | 0     | 0     | 4     | 0     | 0     | 0     | 0     | 0     | 1     | 0     |
| Miscellaneous, Zoöglara, . . . . | 0     | 0     | 6     | 0     | 20    | 0     | 0     | 0     | 0     | 0     | 100   | 0     |
| TOTAL, . . . .                   | 21    | 26    | 10    | 14    | 1,360 | 1,647 | 430   | 95    | 105   | 537   | 618   | 878   |

**WINCHESTER.***Chemical Examination of Water from the Middle Reservoir of the Winchester Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|------------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.       | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |             |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                  |                |        |                         |                   |          | Total.      | Dissolved. | Sus-pended. |           |             |           |                  |           |
| 1895.   |                     |                  |                |        |                         |                   |          |             |            |             |           |             |           |                  |           |
| 13587   | Jan. 2              | Distinct.        | Slight.        | .72    | 6.60                    | 3.95              | .0158    | .0928       | .0758      | .0170       | .50       | .0080       | .0000     | 1.0241           | 1.8       |
| 13765   | Feb. 5              | Slight.          | Cons.          | .20    | 4.05                    | 1.00              | .0062    | .0342       | .0176      | .0166       | .44       | .0070       | .0000     | 0.3263           | 1.1       |
| 13923   | Mar. 5              | Distinct, green. | Cons., green.  | .60    | 5.90                    | 3.30              | .0152    | .0880       | .0566      | .0314       | .48       | .0070       | .0000     | 0.9278           | 1.4       |
| 14082   | Apr. 2              | Decided.         | Cons., gray.   | .08    | 2.05                    | 0.90              | .0022    | .0610       | .0258      | .0352       | .16       | .0040       | .0000     | 0.2032           | 0.2       |
| 14248   | May 6               | Distinct.        | Cons., green.  | .48    | 4.70                    | 2.80              | .0014    | .0670       | .0410      | .0260       | .42       | .0100       | .0004     | 0.7161           | 1.3       |
| 14412   | June 4              | Decided.         | Slight, brown. | .58    | 5.80                    | 3.75              | .0078    | .1156       | .0806      | .0550       | .39       | .0010       | .0000     | 0.8664           | 1.1       |
| 14590   | July 9              | Decided, green.  | Cons., green.  | .50    | 5.10                    | 3.05              | .0014    | .0688       | .0478      | .0210       | .41       | .0000       | .0000     | 0.7979           | 1.4       |
| 14773   | Aug. 6              | Decided.         | Slight.        | .37    | 5.20                    | 2.40              | .0070    | .0522       | .0480      | .0042       | .47       | .0100       | .0002     | 0.7722           | 1.6       |
| 14969   | Sept. 3             | Decided, green.  | Cons., yellow. | .30    | 4.85                    | 2.20              | .0036    | .0630       | .0392      | .0238       | .45       | .0030       | .0003     | 0.7045           | 1.3       |
| 15299   | Oct. 2              | Decided, green.  | Cons., green.  | .37    | 4.70                    | 2.40              | .0000    | .0752       | .0468      | .0284       | .46       | .0030       | .0000     | 0.6903           | 1.7       |
| 15478   | Nov. 5              | Decided, green.  | Slight, green. | .35    | 4.50                    | 2.45              | .0044    | .0600       | .0482      | .0118       | .42       | .0140       | .0001     | 0.6566           | 1.3       |
| 15661   | Dec. 3              | Decided, green.  | Cons., green.  | .42    | 4.60                    | 2.75              | .0002    | .0532       | .0466      | .0066       | .36       | .0090       | .0000     | 0.7605           | 1.1       |
| Av.     | 1895                | .....            | .....          | .41    | 4.84                    | 2.58              | .0054    | .0693       | .0462      | .0231       | .41       | .0065       | .0001     | 0.7035           | 1.3       |
| Av.     | 1894                | .....            | .....          | .79    | 5.48                    | 3.02              | .0045    | .0723       | .0485      | .0238       | .44       | .0032       | .0001     | 0.8645           | 1.5       |

**NOTE** to analyses of 1895: Odor, generally distinctly vegetable, frequently becoming stronger on heating. In April the odor was decidedly oily on heating. — The samples were collected from the reservoir, above the dam.

There is no way of drawing water directly from this reservoir for the supply of the town. The overflow from it passes into the South Reservoir.

## WINCHESTER.

*Microscopical Examination of Water from the Middle Reservoir of the Winchester Water Works.*

[Number of organisms per cubic centimeter.]

|                            | 1895. |       |       |       |       |       |        |       |       |       |       |       |
|----------------------------|-------|-------|-------|-------|-------|-------|--------|-------|-------|-------|-------|-------|
|                            | Jan.  | Feb.  | Mar.  | Apr.  | May.  | June. | July.  | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .  | 4     | 6     | 7     | 3     | 7     | 5     | 10     | 8     | 5     | 3     | 6     | 4     |
| Number of sample, . . .    | 13587 | 13765 | 13923 | 14082 | 14248 | 14412 | 14590  | 14773 | 14960 | 15299 | 15478 | 15661 |
| PLANTS.                    |       |       |       |       |       |       |        |       |       |       |       |       |
| Diatomaceæ, . . .          | 58    | 9     | 18    | 480   | 789   | 0     | 16,700 | 10    | 4     | 750   | 4     | 22    |
| Asterionella, . . .        | 0     | 0     | 0     | 0     | 0     | 0     | 0      | 0     | 0     | 0     | 0     | 12    |
| Fragilaria, . . .          | 0     | 0     | 0     | 0     | 1     | 0     | 16,400 | 8     | 0     | 0     | 0     | 0     |
| Synedra, . . .             | 56    | 9     | 18    | 480   | 788   | 0     | 300    | 2     | 4     | 750   | 4     | 8     |
| Tabellaria, . . .          | 0     | 0     | 0     | 0     | 0     | 0     | 0      | 0     | 0     | 0     | 0     | 2     |
| Cyanophyceæ, . . .         | 36    | 28    | 184   | 60    | 0     | 2,850 | 1,450  | 24    | 0     | 352   | 44    | 8     |
| Anabæna, . . .             | 0     | 0     | 0     | 0     | 0     | 2,850 | 0      | 0     | 0     | 0     | 0     | 0     |
| Clathrocystis, . . .       | 0     | 0     | 0     | 0     | 0     | 0     | 650    | 0     | 0     | 2     | 18    | 2     |
| Cælosphaerium, . . .       | 36    | 28    | 184   | 60    | 0     | 200   | 0      | 0     | 0     | 50    | 16    | 6     |
| Microcystis, . . .         | 0     | 0     | 0     | 0     | 0     | 0     | 800    | 0     | 0     | 300   | 10    | 0     |
| Oscillaria, . . .          | 0     | 0     | 0     | 0     | 0     | 0     | 0      | 24    | 0     | 0     | 0     | 0     |
| Algae, . . .               | 0     | 0     | 2     | 0     | 195   | 55    | 16,050 | 94    | 642   | 2,300 | 1,676 | 5,282 |
| Arthrodesmus, . . .        | 0     | 0     | 0     | 0     | 0     | 50    | 0      | 0     | 0     | 0     | 0     | 0     |
| Celastrum, . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 0      | 0     | 0     | 650   | 0     | 0     |
| Cosmarium, . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 16,000 | 3     | 0     | 0     | 0     | 0     |
| Glæocapsa, . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 0      | 4     | 0     | 50    | 0     | 0     |
| Pediastrum, . . .          | 0     | 0     | 0     | 0     | 2     | 0     | 0      | 0     | 2     | 100   | 4     | 0     |
| Protococcus, . . .         | 0     | 0     | 0     | 0     | 76    | 0     | 0      | 6     | 108   | 100   | 0     | 0     |
| Raphidium, . . .           | 0     | 0     | 0     | 0     | 61    | 0     | 50     | 76    | 336   | 0     | 1,324 | 2,360 |
| Scenedesmus, . . .         | 0     | 0     | 0     | 0     | 36    | 0     | 0      | 3     | 4     | 0     | 312   | 2,736 |
| Selenastrum, . . .         | 0     | 0     | 0     | 0     | 0     | 0     | 0      | 0     | 0     | 0     | 26    | 160   |
| Staurastrum, . . .         | 0     | 0     | 0     | 0     | 0     | 0     | 0      | 2     | 192   | 1,300 | 10    | 0     |
| Volvox, . . .              | 0     | 0     | 0     | 0     | 0     | 5     | 0      | 0     | 0     | 0     | 0     | 0     |
| Zoospores, . . .           | 0     | 0     | 2     | 0     | 20    | 0     | 0      | 0     | 0     | 100   | 0     | 6     |
| Fungi, Crenothrix, . . .   | 0     | 0     | 0     | 0     | 0     | 0     | 50     | 19    | 0     | 0     | 0     | 0     |
| ANIMALS.                   |       |       |       |       |       |       |        |       |       |       |       |       |
| Rhizopoda, Arcella, . . .  | 0     | 0     | 0     | 0     | 0     | 0     | 0      | 0     | 0     | 0     | 0     | 2     |
| Infusoria, . . .           | 50    | 1,049 | 470   | 1,191 | 306   | 0     | 2,000  | 96    | 808   | 850   | 129   | 166   |
| Ciliated Infusorian, . . . | 0     | 0     | 0     | 0     | 0     | 0     | 0      | 0     | 0     | 600   | 0     | 0     |
| Dinobryon, . . .           | 0     | 2     | 8     | 1,040 | 0     | 0     | 0      | 0     | 0     | 0     | 0     | 50    |
| Dinobryon cases, . . .     | 0     | 3     | 72    | 0     | 0     | 0     | 0      | 0     | 240   | 0     | 0     | 0     |
| Euglena, . . .             | 0     | 5     | 88    | 100   | 0     | 0     | 0      | 0     | 0     | 0     | 4     | 4     |
| Mallomonas, . . .          | 0     | 0     | 6     | 0     | 1     | 0     | 0      | 0     | 488   | 0     | 0     | 0     |
| Monas, . . .               | 0     | 0     | 0     | 6     | 0     | 0     | 200    | 0     | 0     | 100   | 1     | 0     |
| Paramecium, . . .          | 0     | 0     | 0     | 0     | 0     | 0     | 0      | 0     | 0     | 50    | 0     | 0     |
| Peridinium, . . .          | 44    | 19    | 72    | 5     | 116   | 0     | 0      | 44    | 22    | 0     | 64    | 108   |
| Trachelomonas, . . .       | 6     | 1,020 | 224   | 40    | 188   | 0     | 1,800  | 82    | 48    | 100   | 60    | 4     |
| Vorticella, . . .          | 0     | 0     | 0     | 0     | 1     | 0     | 0      | 0     | 10    | 0     | 0     | 0     |
| Vermes, . . .              | 2     | 0     | 4     | 0     | 1     | 0     | 0      | 0     | 4     | 0     | 38    | 24    |
| Anura, . . .               | 0     | 0     | 0     | 0     | 0     | 0     | 0      | 0     | 4     | 0     | 36    | 24    |
| Polyarthra, . . .          | 2     | 0     | 4     | 0     | 1     | 0     | 0      | 0     | 0     | 0     | 0     | 0     |
| Crustacea, . . .           | 0     | 0     | 0     | 0     | 0     | 3     | 0      | 0     | 0     | 0     | .04   | 0     |
| Bosmina, . . .             | 0     | 0     | 0     | 0     | 0     | 2     | 0      | 0     | 0     | 0     | 0     | 0     |
| Daphnia, . . .             | 0     | 0     | 0     | 0     | 0     | 1     | 0      | 0     | 0     | 0     | .04   | 0     |
| Miscellaneous.             |       |       |       |       |       |       |        |       |       |       |       |       |
| Acarina, . . .             | 0     | 0     | 0     | 0     | 0     | 0     | 0      | .04   | 0     | 0     | .04   | 0     |
| Zoöglæa, . . .             | 0     | 0     | 0     | 0     | 0     | 24    | 0      | 0     | 0     | 0     | 0     | 0     |
| TOTAL, . . .               | 144   | 1,086 | 678   | 1,731 | 1,315 | 2,908 | 36,250 | 243   | 1,458 | 4,252 | 1,889 | 5,484 |

## WOBURN.

## WATER SUPPLY OF WOBBURN.

*Chemical Examination of Water from the Filter-gallery of the Woburn Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | Residue on Evaporation | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|------------|--------|------------------------|----------|---------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment.  | Color. |                        | Free.    | Albu- minoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 1895.   |                     |             |            |        |                        |          |               |           |             |           |                  |           |       |
| 13606   | Jan. 7              | None.       | None.      | .01    | 10.60                  | .0028    | .0042         | 1.90      | .0240       | .0000     | .0507            | 5.0       | .0000 |
| 13622   | Jan. 7              | None.       | V. slight. | .02    | 11.00                  | .0032    | .0046         | 1.95      | .0260       | .0000     | .0507            | 5.0       | .0000 |
| 13623   | Jan. 8              | None.       | None.      | .02    | 11.50                  | .0028    | .0044         | 1.91      | .0240       | .0000     | .0507            | 5.0       | .0000 |
| 13653   | Jan. 14             | None.       | V. slight. | .03    | 10.70                  | .0068    | .0030         | 1.76      | .0120       | .0000     | .0671            | 4.9       | .0000 |
| 13727   | Jan. 28             | None.       | None.      | .00    | 10.10                  | .0018    | .0026         | 1.72      | .0150       | .0000     | .0395            | 4.7       | .0000 |
| 13728   | Jan. 28             | None.       | None.      | .03    | 11.10                  | .0036    | .0026         | 1.88      | .0300       | .0002     | .0379            | 4.9       | .0000 |
| 13729   | Jan. 28             | None.       | None.      | .03    | 11.00                  | .0030    | .0012         | 1.94      | .0200       | .0005     | .0490            | 5.1       | .0000 |
| 13842   | Feb. 19             | None.       | None.      | .03    | 10.80                  | .0030    | .0022         | 1.78      | .0220       | .0000     | .0312            | 4.7       | .0000 |
| 13998   | Mar. 19             | None.       | V. slight. | .01    | 10.40                  | .0018    | .0020         | 1.76      | .0230       | .0000     | .0592            | 4.9       | .0010 |
| 14172   | Apr. 17             | None.       | None.      | .01    | 11.10                  | .0022    | .0012         | 1.79      | .0280       | .0000     | .0711            | 4.4       | .0000 |
| 14334   | May 21              | None.       | None.      | .02    | 10.65                  | .0024    | .0016         | 1.73      | .0180       | .0000     | .0355            | 4.6       | .0020 |
| 14503   | June 19             | None.       | None.      | .00    | 11.20                  | .0026    | .0018         | 1.72      | .0230       | .0000     | .0186            | 5.0       | .0010 |
| 14698   | July 23             | None.       | None.      | .01    | 10.95                  | .0022    | .0018         | 1.76      | .0280       | .0000     | .0600            | 5.4       | .0190 |
| 14854   | Aug. 19             | None.       | None.      | .00    | 11.10                  | .0044    | .0028         | 1.70      | .0170       | .0000     | .0624            | 5.4       | .0000 |
| 15171   | Sept. 16            | None.       | None.      | .00    | 11.95                  | .0044    | .0020         | 1.73      | .0100       | .0000     | .0640            | 4.7       | .0015 |
| 15359   | Oct. 14             | None.       | None.      | .01    | 10.20                  | .0032    | .0020         | 1.67      | .0150       | .0000     | .0636            | 4.9       | .0010 |
| 15556   | Nov. 18             | None.       | None.      | .00    | 10.00                  | .0038    | .0022         | 1.72      | .0156       | .0000     | .0686            | 4.6       | .0015 |
| 15741   | Dec. 17             | None.       | V. slight. | .01    | 10.60                  | .0038    | .0038         | 1.71      | .0240       | .0000     | .0731            | 5.0       | .0010 |
| Av.*    | .....               | .....       | .....      | .01    | 10.82                  | .0031    | .0022         | 1.74      | .0204       | .0000     | .0570            | 4.9       | .0023 |

*Averages by Years.*

|   |       |   |   |     |       |       |       |      |       |       |       |     |       |
|---|-------|---|---|-----|-------|-------|-------|------|-------|-------|-------|-----|-------|
| - | 1887† | - | - | .00 | 12.06 | -     | .0028 | 2.40 | .0314 | -     | -     | -   | -     |
| - | 1888  | - | - | .00 | 12.00 | .0012 | .0032 | 2.50 | .0346 | .0000 | -     | -   | -     |
| - | 1889  | - | - | .00 | 10.84 | .0010 | .0022 | 2.07 | .0372 | .0000 | -     | -   | -     |
| - | 1890  | - | - | .01 | 11.06 | .0012 | .0023 | 1.91 | .0481 | .0000 | -     | 5.0 | -     |
| - | 1891  | - | - | .00 | 10.85 | .0008 | .0015 | 1.79 | .0668 | .0000 | -     | 4.9 | -     |
| - | 1892  | - | - | .00 | 11.27 | .0012 | .0024 | 1.95 | .0542 | .0000 | -     | 5.1 | -     |
| - | 1893  | - | - | .00 | 11.50 | .0022 | .0018 | 2.04 | .0447 | .0000 | .0517 | 5.3 | .0004 |
| - | 1894  | - | - | .01 | 11.02 | .0026 | .0018 | 1.94 | .0262 | .0000 | .0501 | 5.0 | .0021 |
| - | 1895  | - | - | .01 | 10.82 | .0031 | .0022 | 1.74 | .0204 | .0000 | .0570 | 4.9 | .0023 |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.  
 † June to December.

NOTE to analyses of 1895: Odor, none. — The samples were collected from the filter-gallery.

*Microscopical Examination.*

An insignificant number of organisms was found in the samples collected in January, February, May and October, and no organisms in the other samples.

## WOBURN.

*Chemical Examination of Water from Horn Pond, Woburn.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |          | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------------|-------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|----------|------------------|-----------|
|         |                     | Turbidity.          | Sediment.         | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrate.    | Nitrite. |                  |           |
|         |                     |                     |                   |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |          |                  |           |
| 13652   | 1895.<br>Jan. 14    | Slight.             | Slight.           | .45    | 8.85                    | 2.45              | .0196    | .0326       | .0210      | .0116      | 1.32      | .0970       | .0002    | .5372            | 3.0       |
| 13841   | Feb. 19             | Distinct.           | Slight.           | .45    | 9.75                    | 2.70              | .0142    | .0218       | .0170      | .0048      | 1.50      | .1100       | .0004    | .4173            | 3.5       |
| 14171   | Apr. 17             | Slight.             | Cons.<br>green.   | .30    | 9.55                    | 2.90              | .0000    | .0272       | .0178      | .0094      | 1.55      | .0830       | .0030    | .4582            | 3.4       |
| 14333   | May 21              | Decided.            | Cons.<br>green.   | .40    | 9.15                    | 3.20              | .0004    | .0342       | .0202      | .0140      | 1.42      | .0620       | .0020    | .5214            | 3.0       |
| 14502   | June 19             | Distinct.           | Slight.           | .38    | 9.65                    | 4.40              | .0034    | .0234       | .0248      | .0036      | 1.54      | .0400       | .0020    | .4228            | 3.5       |
| 14677   | July 23             | Slight.             | Cons.             | .35    | 9.45                    | 2.30              | .0000    | .0314       | .0190      | .0124      | 1.65      | .0300       | .0022    | .4350            | 3.6       |
| 14853   | Aug. 19             | Distinct.<br>green. | Cons.<br>green.   | .20    | 9.25                    | 2.15              | .0000    | .0342       | .0210      | .0132      | 1.66      | .0080       | .0015    | .4836            | 3.6       |
| 15170   | Sept. 16            | Decided.<br>green.  | Slight.<br>green. | .30    | 9.95                    | 2.25              | .0002    | .0290       | .0202      | .0088      | 1.80      | .0030       | .0003    | .4606            | 3.4       |
| 16358   | Oct. 14             | Distinct.           | Cons.             | .23    | 9.25                    | 2.30              | .0462    | .0328       | .0222      | .0106      | 1.74      | .0140       | .0005    | .4485            | 3.6       |
| 16556   | Nov. 18             | Distinct.<br>green. | Slight.           | .40    | 9.40                    | 3.00              | .0092    | .0322       | .0206      | .0116      | 1.47      | .0280       | .0018    | .5334            | 3.2       |
| 15740   | Dec. 17             | Slight.             | Slight.           | .48    | 9.45                    | 3.55              | .0030    | .0232       | .0222      | .0010      | 1.14      | .1050       | .0014    | .5582            | 3.1       |
| Av.     | .....               | .....               | .....             | .36    | 9.43                    | 2.84              | .0087    | .0297       | .0205      | .0092      | 1.58      | .0523       | .0014    | .4850            | 3.4       |

*Averages by Years.*

|   |       |   |   |     |       |      |       |       |       |       |      |       |       |       |     |
|---|-------|---|---|-----|-------|------|-------|-------|-------|-------|------|-------|-------|-------|-----|
| - | 1887* | - | - | .44 | 13.79 | 2.19 | .0149 | .0480 | -     | -     | 3.74 | .0224 | .0014 | -     | -   |
| - | 1888  | - | - | .32 | 11.28 | 1.71 | .0186 | .0383 | -     | -     | 2.98 | .0398 | .0015 | -     | -   |
| - | 1889  | - | - | .30 | 8.37  | 2.03 | .0092 | .0376 | .0216 | .0160 | 1.98 | .0498 | .0015 | -     | -   |
| - | 1890  | - | - | .27 | 10.76 | 2.07 | .0080 | .0368 | .0205 | .0163 | 1.91 | .0581 | .0008 | -     | 3.4 |
| - | 1891  | - | - | .22 | 8.90  | 2.06 | .0129 | .0453 | .0237 | .0216 | 1.76 | .0502 | .0009 | -     | 2.9 |
| - | 1892  | - | - | .25 | 10.57 | 2.13 | .0110 | .0358 | .0216 | .0142 | 2.42 | .0821 | .0008 | -     | 3.3 |
| - | 1893  | - | - | .30 | 9.83  | 2.51 | .0061 | .0455 | .0247 | .0208 | 2.10 | .0472 | .0009 | .4530 | 3.2 |
| - | 1894  | - | - | .33 | 9.03  | 1.98 | .0065 | .0292 | .0184 | .0108 | 1.84 | .0404 | .0009 | .4038 | 3.3 |
| - | 1895  | - | - | .36 | 9.43  | 2.84 | .0087 | .0297 | .0205 | .0092 | 1.53 | .0523 | .0014 | .4850 | 3.4 |

\* June to December.

NOTE to analyses of 1895: Odor, distinctly vegetable; often also mouldy or unpleasant. — The samples were collected from the pond at its outlet, 1 foot beneath the surface.

## WOBURN.

*Microscopical Examination of Water from Horn Pond, Woburn.*

[Number of organisms per cubic centimeter.]

|                                 | 1895. |       |       |       |       |       |       |       |       |       |       |  |
|---------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--|
|                                 | Jan.  | Feb.  | Apr.  | May.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |  |
| Day of examination, . . . .     | 15    | 20    | 18    | 21    | 20    | 24    | 20    | 17    | 15    | 20    | 18    |  |
| Number of sample, . . . .       | 13652 | 13841 | 14171 | 14333 | 14502 | 14677 | 14853 | 15170 | 15358 | 15555 | 15740 |  |
| PLANTS.                         |       |       |       |       |       |       |       |       |       |       |       |  |
| Diatomaceæ, . . . .             | 34    | 8     | 2,022 | 7,530 | 1     | 50    | 59    | 1,020 | 68    | 525   | 223   |  |
| Asterionella, . . . .           | 33    | 3     | 1,920 | 3,200 | 0     | 0     | 0     | 0     | 12    | 104   | 40    |  |
| Cyclotella, . . . .             | 0     | pr.   | 0     | 0     | 0     | 0     | 24    | 1,020 | 3     | 0     | 2     |  |
| Diatoma, . . . .                | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 14    | 8     | 3     |  |
| Fragilaria, . . . .             | 0     | 0     | 0     | 4,320 | 0     | 50    | 33    | 0     | 9     | 0     | 0     |  |
| Melosira, . . . .               | 0     | 1     | 96    | 0     | 0     | 0     | 0     | 0     | 29    | 268   | 105   |  |
| Synedra, . . . .                | 0     | 1     | 6     | 10    | 1     | 0     | 2     | 0     | 0     | 128   | 73    |  |
| Tabellaria, . . . .             | 1     | pr.   | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 17    | 0     |  |
| Cyanophyceæ, . . . .            | 1     | 0     | 0     | 0     | 15    | 28    | 675   | 25    | 4     | 0     | 0     |  |
| Anabaena, . . . .               | 0     | 0     | 0     | 0     | 0     | 0     | 43    | 23    | 2     | 0     | 0     |  |
| Chroococcus, . . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 624   | 0     | 0     | 0     | 0     |  |
| Clathrocystis, . . . .          | 0     | 0     | 0     | 0     | 0     | 28    | 0     | 2     | 2     | 0     | 0     |  |
| Colosphaerium, . . . .          | 1     | 0     | 0     | 0     | 15    | 0     | 2     | 0     | 0     | 0     | 0     |  |
| Microcystis, . . . .            | 0     | 0     | 0     | 0     | 0     | 0     | 6     | 0     | 0     | 0     | 0     |  |
| Algae, . . . .                  | 1     | 1     | 4     | 8     | 568   | 282   | 1,928 | 225   | 126   | 34    | 12    |  |
| Arthrodesmus, . . . .           | 0     | 0     | 0     | 0     | 0     | 0     | 188   | 0     | 0     | 1     | 0     |  |
| Chlorococcus, . . . .           | 0     | 1     | 0     | 0     | 0     | 0     | 228   | 0     | 0     | 0     | 0     |  |
| Cosmarium, . . . .              | 0     | 0     | 0     | 2     | 0     | 69    | 0     | 180   | 108   | 1     | 0     |  |
| Pandorina, . . . .              | 0     | 0     | 0     | 0     | 0     | 48    | 0     | 0     | 0     | 0     | 0     |  |
| Protococcus, . . . .            | 0     | 0     | 0     | 0     | 520   | 102   | 1,008 | 0     | 4     | 2     | 0     |  |
| Raphidium, . . . .              | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 8     | 0     | 28    | 0     |  |
| Scenedesmus, . . . .            | 1     | 0     | 1     | 4     | 44    | 56    | 504   | 7     | 12    | 0     | 11    |  |
| Staurostrum, . . . .            | 0     | 0     | 0     | 2     | 4     | 14    | 0     | 28    | 2     | 0     | 0     |  |
| Zoëspores, . . . .              | 0     | 0     | 3     | 0     | 0     | 0     | 0     | 2     | 0     | 2     | 1     |  |
| Fungi, Crenothrix, . . . .      | 52    | 2     | 4     | 0     | 0     | 4     | 0     | 0     | 1     | 0     | 0     |  |
| ANIMALS.                        |       |       |       |       |       |       |       |       |       |       |       |  |
| Rhizopoda, Actinophrys, . . . . | 0     | 0     | 0     | 0     | 0     | 4,800 | 0     | 0     | 0     | 0     | 0     |  |
| Infusoria, . . . .              | 11    | 4     | 7     | 0     | 0     | 48    | 377   | 1     | 30    | 16    | 0     |  |
| Cryptomonas, . . . .            | 9     | pr.   | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |  |
| Euglena, . . . .                | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 24    | 0     | 0     |  |
| Mallomonas, . . . .             | 0     | 0     | 5     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |  |
| Monas, . . . .                  | 0     | 0     | 0     | 0     | 0     | 0     | 20    | 1     | 0     | 2     | 0     |  |
| Peridinium, . . . .             | 0     | 1     | 2     | 0     | 0     | 48    | 357   | 0     | 2     | 4     | 0     |  |
| Trachelomonas, . . . .          | 2     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 4     | 10    | 0     |  |
| Vermes, . . . .                 | 0     | 0     | 1     | 14    | 0     | 2     | 2     | 2     | 4     | 0     | 0     |  |
| Anurea, . . . .                 | 0     | 0     | 0     | 6     | 0     | 2     | 1     | 0     | 1     | 0     | 0     |  |
| Polyarthra, . . . .             | 0     | 0     | 0     | 4     | 0     | 0     | 1     | 0     | 0     | 0     | 0     |  |
| Rotatorian ova, . . . .         | 0     | 0     | 1     | 4     | 0     | 0     | 0     | 2     | 3     | 0     | 0     |  |
| Miscellaneous, Zoëglæa, . . . . | 72    | 3     | 0     | 0     | 0     | 0     | 0     | 72    | 160   | 100   | 60    |  |
| TOTAL, . . . .                  | 171   | 16    | 2,039 | 7,562 | 594   | 5,214 | 3,041 | 1,345 | 393   | 675   | 295   |  |

## WATER SUPPLY OF WORCESTER.

In the latter part of 1894, the Lynde Brook Reservoir becoming nearly exhausted, a temporary connection was made between this Reservoir and Kettle Brook, and water was drawn from the latter source for the supply of the city. Early in 1895 the city of

## WORCESTER.

Worcester decided to make Kettle Brook a permanent addition to its water supply system, and laid a 30-inch cast iron pipe conduit from the Kent Reservoir, on Kettle Brook, to the Lynde Brook Reservoir.

Above Kent Reservoir, on Kettle Brook, are three other reservoirs, known as the Mann Reservoir, Bottomly Pond and the Arnold Reservoir. Analyses of water from the Lynde Brook and Holden storage reservoirs and from the reservoirs on Kettle Brook are given in the tables which follow.

The advice of the State Board of Health to the city of Worcester relative to the use of Kettle Brook as an additional source of water supply for the city may be found on pages 57 and 58 of this volume.

LEICESTER SUPPLY. — *Chemical Examination of Water from Lynde Brook Storage Reservoir.*

[Parts per 100,000.]

| Number.  | Date of Collection. | APPEARANCE.         |                      |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|----------|---------------------|---------------------|----------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|          |                     | Turbidity.          | Sediment.            | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|          |                     |                     |                      |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.    |                     |                     |                      |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 13556    | Jan. 14             | Slight.             | Slight.              | .45    | 4.70                    | 1.50              | .0028    | .0152       | .0144      | .0008      | .25       | .0250       | .0000     | .4961            | 1.9       |
| 13852    | Feb. 19             | None.               | V. slight.           | .52    | 5.45                    | 1.45              | .0046    | .0166       | .0142      | .0024      | .29       | .0300       | .0000     | .5889            | 1.7       |
| 14004    | Mar. 19             | V. slight.          | Slight.              | .38    | 3.25                    | 0.95              | .0030    | .0134       | .0116      | .0018      | .19       | .0200       | .0000     | .4740            | 1.3       |
| 14141    | Apr. 15             | Distinct.           | Slight.              | .28    | 3.45                    | 1.30              | .0040    | .0128       | .0094      | .0034      | .19       | .0200       | .0001     | .4187            | 1.1       |
| 14326    | May 19              | V. slight.          | V. slight.           | .25    | 3.30                    | 1.30              | .0014    | .0134       | .0122      | .0012      | .23       | .0100       | .0000     | .4029            | 1.3       |
| 14486    | June 18             | Slight.             | Slight.              | .23    | 3.50                    | 1.55              | .0004    | .0172       | .0142      | .0030      | .18       | .0070       | .0000     | .3627            | 0.6       |
| 14663    | July 22             | V. slight.          | Slight.              | .20    | 3.10                    | 1.05              | .0004    | .0164       | .0146      | .0018      | .18       | .0000       | .0000     | .3825            | —         |
| 14865    | Aug. 19             | V. slight.          | V. slight.           | .18    | 3.20                    | 1.15              | .0008    | .0164       | .0150      | .0014      | .20       | .0000       | .0000     | .3510            | 1.3       |
| 15174    | Sept. 16            | V. slight.          | V. slight.<br>green. | .20    | 3.70                    | 1.40              | .0002    | .0150       | .0134      | .0016      | .25       | .0000       | .0001     | .3900            | 1.3       |
| 15366    | Oct. 14             | Decided,<br>clayey. | Cons.                | .30    | 3.55                    | 1.15              | .0096    | .0230       | .0178      | .0052      | .20       | .0070       | .0000     | .5031            | 0.9       |
| 15564    | Nov. 17             | Slight.             | Slight.              | .33    | 3.05                    | 1.50              | .0086    | .0168       | .0132      | .0036      | .17       | .0070       | .0001     | .5117            | 0.8       |
| 15745    | Dec. 16             | None.               | Slight.              | .47    | 3.80                    | 1.35              | .0044    | .0174       | .0162      | .0012      | .13       | .0130       | .0001     | .5005            | 1.1       |
| Av. .... | .....               | .....               | .....                | .32    | 3.63                    | 1.30              | .0033    | .0161       | .0138      | .0023      | .20       | .0116       | .0000     | .4485            | 1.2       |

## Averages by Years.

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | .30 | 3.16 | 0.95 | .0057 | .0194 | -     | -     | .15 | .0043 | -     | -     | -   |
| - | 1888  | - | - | .24 | 2.64 | 0.85 | .0037 | .0151 | -     | -     | .14 | .0065 | .0001 | -     | -   |
| - | 1889  | - | - | .24 | 2.54 | 0.60 | .0030 | .0167 | .0138 | .0029 | .15 | .0053 | .0001 | -     | -   |
| - | 1890  | - | - | .21 | 3.07 | 1.15 | .0026 | .0132 | .0107 | .0023 | .14 | .0078 | .0001 | -     | 0.9 |
| - | 1891  | - | - | .24 | 2.83 | 1.03 | .0045 | .0126 | .0101 | .0025 | .12 | .0074 | .0001 | -     | 0.7 |
| - | 1892  | - | - | .25 | 2.99 | 1.15 | .0038 | .0139 | .0113 | .0026 | .15 | .0105 | .0000 | -     | 0.8 |
| - | 1893  | - | - | .26 | 2.66 | 0.98 | .0036 | .0162 | .0122 | .0039 | .15 | .0066 | .0001 | .3465 | 0.6 |
| - | 1894  | - | - | .36 | 3.37 | 1.09 | .0055 | .0139 | .0117 | .0022 | .18 | .0103 | .0000 | .3522 | 1.2 |
| - | 1895  | - | - | .32 | 3.63 | 1.30 | .0038 | .0161 | .0138 | .0023 | .20 | .0116 | .0000 | .4485 | 1.2 |

\* June to December.

NOTE to analyses of 1895: Odor, generally faintly vegetable; in January, September, October and November, distinctly vegetable. On heating, the odor became stronger and also mouldy. — The samples were collected from the reservoir near the gate-house, about 1 foot beneath the surface. For record of heights of water in this reservoir, see page 356.



## WORCESTER.

*Microscopical Examination of Water from Lynde Brook Storage Reservoir.*

[Number of organisms per cubic centimeter.]

|                                        | 1895.    |          |          |           |            |            |              |            |            |            |           |           |
|----------------------------------------|----------|----------|----------|-----------|------------|------------|--------------|------------|------------|------------|-----------|-----------|
|                                        | Jan.     | Feb.     | Mar.     | Apr.      | May.       | June.      | July.        | Aug.       | Sept.      | Oct.       | Nov.      | Dec.      |
| Day of examination, . . . .            | 15       | 20       | 20       | 16        | 21         | 19         | 24           | 20         | 17         | 17         | 21        | 18        |
| Number of sample, . . . .              | 13656    | 13852    | 14004    | 14141     | 14326      | 14486      | 14663        | 14865      | 15174      | 15366      | 15564     | 15745     |
| <b>PLANTS.</b>                         |          |          |          |           |            |            |              |            |            |            |           |           |
| <b>Diatomaceæ, . . . .</b>             | <b>4</b> | <b>1</b> | <b>4</b> | <b>11</b> | <b>9</b>   | <b>84</b>  | <b>120</b>   | <b>11</b>  | <b>23</b>  | <b>7</b>   | <b>29</b> | <b>12</b> |
| Asterionella, . . . .                  | 0        | 0        | 0        | 0         | 9          | 0          | 11           | 0          | 0          | 0          | 19        | 8         |
| Cyclotella, . . . .                    | 1        | 0        | 0        | 8         | 0          | 60         | 0            | 7          | 20         | 1          | 0         | 0         |
| Melosira, . . . .                      | 0        | 0        | 0        | 0         | 0          | 0          | 0            | 1          | 0          | 5          | 6         | 0         |
| Navicula, . . . .                      | 0        | 0        | 1        | 2         | 0          | 0          | 1            | 2          | 0          | 1          | 0         | 0         |
| Stephanodiscus, . . . .                | 0        | 0        | 0        | 0         | 0          | 0          | 108          | 0          | 0          | 0          | 0         | 0         |
| Synedra, . . . .                       | 2        | 1        | 3        | 1         | 0          | 4          | 0            | 1          | 0          | 0          | 4         | 0         |
| Tabellaria, . . . .                    | 1        | 0        | 0        | 0         | 0          | 0          | 0            | 0          | 3          | 0          | 0         | 4         |
| <b>Cyanophyceæ, . . . .</b>            | <b>0</b> | <b>0</b> | <b>0</b> | <b>0</b>  | <b>0</b>   | <b>220</b> | <b>208</b>   | <b>192</b> | <b>68</b>  | <b>6</b>   | <b>0</b>  | <b>0</b>  |
| Chroococcus, . . . .                   | 0        | 0        | 0        | 0         | 0          | 0          | 0            | 188        | 68         | 4          | 0         | 0         |
| Merismopedia, . . . .                  | 0        | 0        | 0        | 0         | 0          | 0          | 208          | 4          | 0          | 0          | 0         | 0         |
| Microcystis, . . . .                   | 0        | 0        | 0        | 0         | 0          | 220        | 0            | 0          | 0          | 2          | 0         | 0         |
| <b>Algæ, . . . .</b>                   | <b>0</b> | <b>0</b> | <b>0</b> | <b>0</b>  | <b>155</b> | <b>11</b>  | <b>1,125</b> | <b>251</b> | <b>48</b>  | <b>57</b>  | <b>0</b>  | <b>0</b>  |
| Chlorococcus, . . . .                  | 0        | 0        | 0        | 0         | 0          | 11         | 0            | 212        | 2          | 12         | 0         | 0         |
| Protococcus, . . . .                   | 0        | 0        | 0        | 0         | 150        | 0          | 1,120        | 29         | 42         | 45         | 0         | 0         |
| Raphidium, . . . .                     | 0        | 0        | 0        | 0         | 4          | 0          | 4            | 0          | 2          | 0          | 0         | 0         |
| Scenedesmus, . . . .                   | 0        | 0        | 0        | 0         | 1          | 0          | 1            | 4          | 0          | 0          | 0         | 0         |
| Staurogenia, . . . .                   | 0        | 0        | 0        | 0         | 0          | 0          | 0            | 6          | 2          | 0          | 0         | 0         |
| <b>Fungi, Crenothrix, . . . .</b>      | <b>2</b> | <b>1</b> | <b>2</b> | <b>27</b> | <b>0</b>   | <b>1</b>   | <b>1</b>     | <b>0</b>   | <b>0</b>   | <b>72</b>  | <b>4</b>  | <b>2</b>  |
| <b>ANIMALS.</b>                        |          |          |          |           |            |            |              |            |            |            |           |           |
| <b>Infusoria, . . . .</b>              | <b>0</b> | <b>1</b> | <b>1</b> | <b>43</b> | <b>1</b>   | <b>0</b>   | <b>1</b>     | <b>7</b>   | <b>1</b>   | <b>7</b>   | <b>6</b>  | <b>4</b>  |
| Dinobryon, . . . .                     | 0        | 0        | 0        | 28        | 0          | 0          | 0            | 0          | 0          | 7          | 0         | 4         |
| Dinobryon cases, . . . .               | 0        | 0        | 1        | 8         | 0          | 0          | 0            | 0          | 0          | 0          | 5         | 0         |
| Peridinium, . . . .                    | 0        | 0        | 0        | 7         | 1          | 0          | 0            | 0          | 0          | 0          | 1         | 0         |
| Trachelomonas, . . . .                 | 0        | 1        | 0        | 0         | 0          | 0          | 1            | 7          | 1          | 0          | 0         | 0         |
| <b>Vermes, Polyarthra, . . . .</b>     | <b>0</b> | <b>0</b> | <b>0</b> | <b>1</b>  | <b>1</b>   | <b>0</b>   | <b>0</b>     | <b>0</b>   | <b>0</b>   | <b>0</b>   | <b>0</b>  | <b>0</b>  |
| <b>Miscellaneous, Zoöglæa, . . . .</b> | <b>0</b> | <b>0</b> | <b>0</b> | <b>0</b>  | <b>50</b>  | <b>0</b>   | <b>0</b>     | <b>92</b>  | <b>0</b>   | <b>400</b> | <b>2</b>  | <b>0</b>  |
| <b>TOTAL, . . . .</b>                  | <b>6</b> | <b>3</b> | <b>7</b> | <b>82</b> | <b>216</b> | <b>296</b> | <b>1,455</b> | <b>553</b> | <b>140</b> | <b>549</b> | <b>41</b> | <b>18</b> |

## WORCESTER.

HOLDEN SUPPLY. — *Chemical Examination of Water from Tatnuck Brook Storage Reservoir.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                  |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.        | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                  |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13657   | 1895.<br>Jan. 14    | Slight.     | Slight.          | .30    | 2.55                    | 1.00              | .0016    | .0158       | .0130      | .0028      | .20       | .0050       | .0000     | .3555            | 0.8       |
| 13853   | Feb. 19             | V. slight.  | V. slight.       | .25    | 2.75                    | 0.80              | .0052    | .0108       | .0096      | .0012      | .20       | .0130       | .0000     | .3120            | 0.6       |
| 14005   | Mar. 19             | V. slight.  | V. slight.       | .20    | 2.35                    | 0.85              | .0028    | .0102       | .0088      | .0016      | .20       | .0050       | .0000     | .3176            | 0.8       |
| 14142   | Apr. 15             | Slight.     | Slight.          | .20    | 2.15                    | 1.00              | .0008    | .0160       | .0112      | .0048      | .17       | .0030       | .0001     | .3120            | 0.5       |
| 14327   | May 19              | Distinct.   | Cons.            | .18    | 2.40                    | 1.00              | .0012    | .0150       | .0098      | .0052      | .18       | .0000       | .0000     | .3120            | 0.6       |
| 14485   | June 18             | Distinct.   | Slight.          | .20    | 2.20                    | 0.80              | .0000    | .0142       | .0120      | .0022      | .16       | .0200       | .0000     | .3058            | 0.3       |
| 14664   | July 22             | Slight.     | Cons.            | .18    | 1.85                    | 1.00              | .0010    | .0196       | .0154      | .0042      | .17       | .0000       | .0000     | .3075            | 0.3       |
| 14866   | Aug. 19             | Distinct.   | Slight.          | .13    | 2.25                    | 1.05              | .0000    | .0262       | .0196      | .0066      | .22       | .0000       | .0000     | .5616            | 0.3       |
| 15173   | Sept. 16            | Distinct.   | Slight.          | .15    | 2.80                    | 1.25              | .0000    | .0198       | .0110      | .0088      | .20       | .0030       | .0002     | .3058            | 0.5       |
| 15367   | Oct. 14             | Distinct.   | Cons.            | .22    | 2.30                    | 1.10              | .0002    | .0246       | .0168      | .0078      | .19       | .0050       | .0000     | .3783            | 0.5       |
| 15565   | Nov. 17             | Distinct.   | Cons.,<br>green. | .23    | 2.25                    | 1.15              | .0004    | .0192       | .0162      | .0030      | .16       | .0030       | .0000     | .4290            | 0.3       |
| 15746   | Dec. 16             | None.       | V. slight.       | .28    | 2.15                    | 0.80              | .0008    | .0158       | .0128      | .0030      | .14       | .0250       | .0000     | .3965            | 0.3       |
| Av.     | .....               | .....       | .....            | .21    | 2.33                    | 0.98              | .0012    | .0173       | .0130      | .0043      | .18       | .0068       | .0000     | .3578            | 0.5       |

*Averages by Years.*

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | .29 | 2.62 | 1.01 | .0007 | .0197 | -     | -     | .14 | .0016 | -     | -     | -   |
| - | 1888  | - | - | .17 | 2.23 | 0.75 | .0012 | .0157 | -     | -     | .12 | .0043 | .0001 | -     | -   |
| - | 1889  | - | - | .19 | 2.04 | 0.57 | .0003 | .0143 | .0112 | .0031 | .12 | .0031 | .0001 | -     | -   |
| - | 1890  | - | - | .17 | 2.68 | 1.24 | .0007 | .0141 | .0102 | .0039 | .13 | .0078 | .0001 | -     | 0.9 |
| - | 1891  | - | - | .17 | 2.30 | 0.94 | .0024 | .0143 | .0102 | .0041 | .11 | .0077 | .0001 | -     | 0.4 |
| - | 1892  | - | - | .20 | 2.52 | 1.03 | .0012 | .0142 | .0113 | .0029 | .12 | .0067 | .0000 | -     | 0.5 |
| - | 1893  | - | - | .35 | 2.45 | 0.93 | .0020 | .0182 | .0140 | .0042 | .14 | .0049 | .0000 | .3594 | 0.5 |
| - | 1894  | - | - | .20 | 2.27 | 0.85 | .0010 | .0151 | .0114 | .0037 | .16 | .0032 | .0000 | .2978 | 0.4 |
| - | 1895  | - | - | .21 | 2.33 | 0.98 | .0012 | .0173 | .0130 | .0043 | .18 | .0068 | .0000 | .3578 | 0.5 |

\* June to December.

NOTE to analyses of 1895: Odor, generally faintly vegetable, rarely unpleasant, frequently stronger on heating. In April, the odor was disagreeable on heating; in May, unpleasant and oily. — The first sample was collected from the reservoir at the end of the 30-inch pipe through the dam; the second, at the outlet below the dam; and the others, from the reservoir at the gate-house, 1 foot beneath the surface.

For record of heights of water in this reservoir, see page 356.

## WORCESTER.

HOLDEN SUPPLY. — *Microscopical Examination of Water from the Tutnuck Brook Storage Reservoir.*

[Number of organisms per cubic centimeter.]

|                                  | 1895. |       |       |       |       |       |       |       |       |       |       |       |
|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                  | Jan.  | Feb.  | Mar.  | Apr.  | May   | June  | July  | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . .        | 15    | 20    | 20    | 16    | 21    | 19    | 24    | 21    | 17    | 17    | 21    | 18    |
| Number of sample, . . .          | 13657 | 13853 | 14005 | 14142 | 14327 | 14485 | 14664 | 14866 | 15173 | 15367 | 15565 | 15746 |
| PLANTS.                          |       |       |       |       |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . . .              | 7     | 2     | 4     | 50    | 324   | 543   | 433   | 325   | 514   | 1,305 | 1,124 | 85    |
| Asterionella, . . . .            | 7     | 0     | 2     | 3     | 2     | 11    | 9     | 2     | 56    | 112   | 592   | 49    |
| Cyclotella, . . . .              | 0     | 0     | 0     | 2     | 2     | 60    | 0     | 7     | 0     | 6     | 0     | 4     |
| Fragilaria, . . . .              | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 6     |
| Melosira, . . . .                | 0     | 0     | 0     | 28    | 47    | 0     | 0     | 0     | 24    | 500   | 348   | 8     |
| Synedra, . . . .                 | 0     | 1     | 1     | 9     | 5     | 2     | 8     | 20    | 0     | 140   | 28    | 0     |
| Tabellaria, . . . .              | 0     | 1     | 1     | 8     | 268   | 568   | 416   | 296   | 424   | 548   | 156   | 19    |
| Cyanophyceæ, . . . .             | 0     | 0     | 0     | 0     | 0     | 4     | 2     | 5     | 8     | 0     | 0     | 0     |
| Anabæna, . . . .                 | 0     | 0     | 0     | 0     | 0     | 0     | 2     | 5     | 6     | 0     | 0     | 0     |
| Microcystis, . . . .             | 0     | 0     | 0     | 0     | 0     | 4     | 0     | 0     | 2     | 0     | 0     | 0     |
| Algeæ, . . . .                   | 1     | 0     | 0     | 16    | 185   | 8     | 31    | 22    | 42    | 84    | 4     | 0     |
| Arthrodesmus, . . . .            | 0     | 0     | 0     | 0     | 1     | 2     | 1     | 4     | 0     | 1     | 0     | 0     |
| Protooccus, . . . .              | 0     | 0     | 0     | 14    | 172   | 0     | 24    | 7     | 0     | 4     | 0     | 0     |
| Raphidium, . . . .               | 0     | 0     | 0     | 0     | 0     | 1     | 2     | 5     | 2     | 10    | 3     | 0     |
| Scenedesmus, . . . .             | 1     | 0     | 0     | 2     | 11    | 2     | 0     | 0     | 0     | 1     | 0     | 0     |
| Staurostrum, . . . .             | 0     | 0     | 0     | 0     | 1     | 1     | 4     | 6     | 40    | 68    | 1     | 0     |
| Fungi, Crenothrix, . . . .       | 2     | 32    | 10    | 1     | 3     | 0     | 0     | 0     | 0     | 0     | 2     | 0     |
| ANIMALS.                         |       |       |       |       |       |       |       |       |       |       |       |       |
| Infusoria, . . . .               | 4     | 8     | 38    | 686   | 68    | 0     | 254   | 138   | 10    | 54    | 3     | 15    |
| Ciliated infusorian, . . . .     | 0     | 0     | 0     | 1     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Cryptomonas, . . . .             | 0     | 0     | 0     | 0     | 50    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon, . . . .               | 0     | 0     | 1     | 432   | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     |
| Dinobryon cases, . . . .         | 0     | 1     | 36    | 244   | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Euglena, . . . .                 | 0     | 0     | pr.   | 0     | 0     | 0     | 0     | 0     | 0     | 52    | 2     | 1     |
| Monas, . . . .                   | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 3     |
| Peridinium, . . . .              | 4     | 7     | 1     | 9     | 9     | 0     | 248   | 134   | 0     | 0     | 1     | 11    |
| Synura, . . . .                  | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Trachelomonas, . . . .           | 0     | 0     | 0     | 0     | 2     | 0     | 3     | 4     | 10    | 2     | 0     | 0     |
| Uroglena, . . . .                | 0     | 0     | 0     | 0     | 3     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Miscellaneous, Zoöglasæ, . . . . | 11    | 0     | 0     | 112   | 132   | 0     | 0     | 20    | 12    | 0     | 40    | 5     |
| TOTAL, . . . .                   | 25    | 42    | 52    | 865   | 712   | 653   | 720   | 510   | 586   | 1,444 | 1,173 | 106   |

## WORCESTER.

*Chemical Examination of Water from Kent Reservoir on Kettle Brook in Leicester.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 15561   | 1895.<br>Nov. 17    | Slight.     | Slight.    | .57    | 3.65                    | 1.90              | .0014    | .0232       | .0174      | .0058      | .17       | .0080       | .0001     | .6669            | 0.8       |
| 15743   | Dec. 16             | V. slight.  | V. slight. | .90    | 4.15                    | 2.05              | .0130    | .0232       | .0220      | .0012      | .13       | .0150       | .0001     | .7969            | 0.8       |

Odor, distinctly vegetable, becoming also mouldy on heating. — The samples were collected from the reservoir near the gate-house.

*Microscopical Examination.*

No. 15561. Diatomaceæ, *Asterionella*, 67; *Cyclotella*, *Melosira*, 4; *Navicula*, 1; *Synedra*, 6; *Tabellaria*, 8. Algæ, *Arthrodesmus*, 1; *Closterium*, *Stauronegia*, 4. Fungi, *Crenothrix*, 3. Infusoria, *Dinobryon*, 74; *Trachelomonas*, 1. Miscellaneous, *Zoëglia*, 20. Total, 191.

No. 15743. Diatomaceæ, *Asterionella*, 12. Algæ, *Eaphidium*, 3; *Zoëspores*, 1. Fungi, *Crenothrix*, 3. Total, 19.

*Chemical Examination of Water from Mann Reservoir on Kettle Brook, Leicester.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------|--------|-------------------------|-------------------|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |             |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                   |        |                         |                   |          | Total.      | Dissolved. | Sus-pended. |           |             |           |                  |           |
| 13826   | 1895.<br>Feb. 15    | V. slight.  | V. slight.        | .40    | 4.15                    | 1.30              | .0130    | .0114       | .0106      | .0008       | .24       | .0180       | .0000     | .4400            | 1.7       |
| 14552   | June 28             | Slight.     | Cons.             | .23    | 2.65                    | 1.15              | .0006    | .0208       | .0134      | .0074       | .18       | .0000       | .0000     | .3927            | 0.9       |
| 14662   | July 22             | Slight.     | Slight.           | .40    | 3.20                    | 1.35              | .0000    | .0202       | .0174      | .0028       | .17       | .0040       | .0000     | .4875            | 1.1       |
| 14864   | Aug. 19             | Distinct.   | Cons.,<br>green.  | .35    | 3.45                    | 1.30              | .0010    | .0278       | .0194      | .0084       | .16       | .0000       | .0000     | .5226            | 0.9       |
| 15176   | Sept. 16            | Distinct.   | Cons.,<br>yellow. | .30    | 4.05                    | 1.80              | .0054    | .0306       | .0218      | .0088       | .19       | .0030       | .0002     | .4540            | 1.3       |
| 15366   | Oct. 14             | Decided.    | Cons.             | .75    | 3.85                    | 2.25              | .0000    | .0278       | .0218      | .0060       | .20       | .0180       | .0000     | .9500            | 0.8       |
| 15563   | Nov. 17             | Slight.     | Slight.           | .60    | 3.30                    | 2.10              | .0066    | .0240       | .0220      | .0020       | .16       | .0070       | .0001     | .7800            | 0.6       |
| 15744   | Dec. 16             | V. slight.  | V. slight.        | .95    | 3.85                    | 2.10              | .0168    | .0248       | .0232      | .0016       | .13       | .0150       | .0001     | .8085            | 0.8       |
| Av.     | .....               | .....       | .....             | .50    | 3.56                    | 1.67              | .0054    | .0234       | .0187      | .0047       | .18       | .0087       | .0000     | .6044            | 1.0       |

Odor, vegetable. — The first sample was collected from the brook at the outlet of the reservoir and the others from the reservoir near the dam, 1 foot beneath the surface.

## WORCESTER.

*Microscopical Examination of Water from Mann Reservoir on Kettle Brook,  
Leicester.*

[Number of organisms per cubic centimeter.]

|                           | 1895. |       |       |       |       |       |       |       |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
|                           | Feb.  | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . | 16    | 29    | 23    | 20    | 17    | 17    | 21    | 18    |
| Number of sample, . . .   | 13825 | 14552 | 14662 | 14864 | 15176 | 15365 | 15563 | 15744 |
| <b>PLANTS.</b>            |       |       |       |       |       |       |       |       |
| Diatomaceæ, . . .         | 9     | 819   | 212   | 266   | 154   | 130   | 282   | 3     |
| Asterionella, . . .       | 0     | 0     | 0     | 29    | 1     | 0     | 224   | 0     |
| Cyclotella, . . .         | 0     | 0     | 176   | 96    | 0     | 0     | 0     | 0     |
| Diatoma, . . .            | 0     | 5     | 0     | 0     | 2     | 4     | 0     | 0     |
| Fragilaria, . . .         | 0     | 0     | 0     | 0     | 0     | 12    | 13    | 0     |
| Melosira, . . .           | 8     | 800   | 33    | 138   | 144   | 68    | 24    | 0     |
| Meridion, . . .           | 0     | 1     | 0     | 0     | 0     | 6     | 0     | 0     |
| Navicula, . . .           | pr.   | 7     | 1     | 1     | 2     | 8     | 1     | 0     |
| Pinnularia, . . .         | 0     | 1     | 1     | 0     | 2     | 2     | 0     | 0     |
| Suriella, . . .           | 0     | 0     | 0     | 0     | 1     | 6     | 0     | 0     |
| Synedra, . . .            | 1     | 3     | 1     | 2     | 2     | 24    | 7     | 0     |
| Tabellaria, . . .         | pr.   | 2     | 0     | 0     | 0     | 0     | 13    | 3     |
| Cyanophyceæ, Anabaena, .  | 0     | 0     | 0     | 0     | 0     | 6     | 0     | 0     |
| Algae, . . .              | pr.   | 44    | 13    | 358   | 30    | 20    | 2     | 5     |
| Arthrodesmus, . . .       | 0     | 0     | 0     | 4     | 0     | 0     | 0     | 0     |
| Chlorococcus, . . .       | 0     | 0     | 0     | 340   | 2     | 0     | 0     | 0     |
| Cosmarium, . . .          | 0     | 0     | 0     | 0     | 3     | 0     | 1     | 0     |
| Gloeocapsa, . . .         | 0     | 2     | 0     | 3     | 0     | 0     | 0     | 0     |
| Pediastrum, . . .         | 0     | 5     | 0     | 0     | 0     | 0     | 0     | 0     |
| Protococcus, . . .        | 0     | 24    | 11    | 0     | 14    | 10    | 0     | 0     |
| Raphidium, . . .          | 0     | 11    | 0     | 1     | 7     | 2     | 1     | 5     |
| Scenedesmus, . . .        | pr.   | 0     | 0     | 8     | 3     | 4     | 0     | 0     |
| Stauroastrum, . . .       | 0     | 2     | 2     | 2     | 1     | 0     | 0     | 0     |
| Staurogenia, . . .        | 0     | 0     | 0     | 0     | 0     | 4     | 0     | 0     |
| Fungi, Crenothrix, . . .  | 0     | 2     | 0     | 5     | 0     | 200   | 10    | 0     |
| <b>ANIMALS.</b>           |       |       |       |       |       |       |       |       |
| Infusoria, . . .          | 0     | 2     | 195   | 19    | 815   | 6     | 18    | 6     |
| Codonella, . . .          | 0     | 0     | 0     | 0     | 1     | 0     | 2     | 0     |
| Dinobryon, . . .          | 0     | 0     | 35    | 6     | 460   | 0     | 16    | 5     |
| Dinobryon cases, . . .    | 0     | 0     | 0     | 0     | 162   | 0     | 0     | 0     |
| Mallomonas, . . .         | 0     | 2     | 0     | 1     | 1     | 0     | 0     | 0     |
| Peridinium, . . .         | 0     | 0     | 160   | 12    | 0     | 0     | 0     | 1     |
| Tintinnidium, . . .       | 0     | 0     | 0     | 0     | 1     | 0     | 0     | 0     |
| Trachelomonas, . . .      | 0     | 0     | 0     | 0     | 0     | 6     | 0     | 0     |
| Vermes, . . .             | 0     | 1     | 0     | 0     | 2     | 2     | 0     | 0     |
| Aurea, . . .              | 0     | 1     | 0     | 0     | 0     | 0     | 0     | 0     |
| Nais, . . .               | 0     | 0     | 0     | 0     | 0     | 2     | 0     | 0     |
| Rotatorian ova, . . .     | 0     | 0     | 0     | 0     | 2     | 0     | 0     | 0     |
| Miscellaneous, Zoöglæa, . | 0     | 0     | 0     | 0     | 0     | 0     | 40    | 0     |
| TOTAL, . . .              | 9     | 868   | 420   | 648   | 801   | 364   | 332   | 14    |

## WORCESTER.

*Chemical Examination of Water from Bottomly Pond, Paxton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
|         |                     |             |                   |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 1895.   |                     |             |                   |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 14551   | June 28             | V. slight.  | Slight.           | 0.25   | 2.75                            | 1.50                 | .0002    | .0166       | .0130      | .0036           | .19       | .0030          | .0000     | .4774            | 0.8       |
| 14661   | July 22             | Slight.     | Cons.             | 0.30   | 3.00                            | 1.50                 | .0006    | .0208       | .0202      | .0006           | .16       | .0000          | .0000     | .5175            | 1.1       |
| 14863   | Aug. 19             | Slight.     | Slight.           | 0.20   | 3.15                            | 1.40                 | .0002    | .0216       | .0202      | .0014           | .16       | .0000          | .0000     | .5928            | 0.8       |
| 15175   | Sept. 16            | Slight.     | Slight.<br>green. | 0.30   | 4.00                            | 1.85                 | .0004    | .0252       | .0214      | .0038           | .20       | .0030          | .0002     | .5320            | 0.9       |
| 15364   | Oct. 14             | Slight.     | Cons.             | 0.35   | 3.40                            | 1.65                 | .0000    | .0264       | .0218      | .0046           | .20       | .0070          | .0000     | .5772            | 1.1       |
| 15560   | Nov. 17             | Slight.     | Slight.           | 0.70   | 3.55                            | 2.25                 | .0158    | .0286       | .0260      | .0026           | .14       | .0050          | .0001     | .8073            | 1.1       |
| 15742   | Dec. 16             | V. slight.  | Cons.             | 1.10   | 4.75                            | 2.75                 | .0220    | .0422       | .0334      | .0088           | .14       | .0220          | .0004     | .9563            | 1.3       |
| Av.     | .....               | .....       | .....             | 0.46   | 3.51                            | 1.84                 | .0056    | .0259       | .0223      | .0036           | .17       | .0057          | .0001     | .6372            | 1.0       |

Odor, distinctly vegetable, except in December, when it was faintly oily, becoming stronger on heating.—The samples were collected from the pond near the dam, 1 foot beneath the surface.

*Microscopical Examination of Water from Bottomly Pond, Paxton.*

[Number of organisms per cubic centimeter.]

|                               | 1895. |       |       |       |       |       |       |
|-------------------------------|-------|-------|-------|-------|-------|-------|-------|
|                               | June. | July. | Aug.  | Sept. | Oct.  | Nov.  | Dec.  |
| Day of examination, . . . . . | 29    | 23    | 20    | 17    | 17    | 21    | 18    |
| Number of sample, . . . . .   | 14551 | 14661 | 14863 | 15175 | 15364 | 15560 | 15742 |
| <b>PLANTS.</b>                |       |       |       |       |       |       |       |
| Diatomaceæ, . . . . .         | 26    | 19    | 352   | 272   | 44    | 99    | 32    |
| Asterionella, . . . . .       | 0     | 0     | 184   | 24    | 23    | 96    | 10    |
| Cyclotella, . . . . .         | 3     | 12    | 168   | 248   | 16    | 0     | 18    |
| Melosira, . . . . .           | 25    | 0     | 0     | 0     | 0     | 0     | 0     |
| Navicula, . . . . .           | 0     | 2     | 0     | 0     | 0     | 2     | 0     |
| Synedra, . . . . .            | 0     | 3     | 0     | 0     | 2     | 1     | 0     |
| Tabellaria, . . . . .         | 0     | 2     | 0     | 0     | 3     | 0     | 4     |
| Cyanophyceæ, . . . . .        | 0     | 23    | 9     | 8     | 8     | 0     | 0     |
| Anabaena, . . . . .           | 0     | 0     | 0     | 8     | 0     | 0     | 0     |
| Anabaena spores, . . . . .    | 0     | 5     | 0     | 0     | 0     | 0     | 0     |
| Chroococcus, . . . . .        | 0     | 0     | 9     | 0     | 0     | 0     | 0     |
| Merismopedia, . . . . .       | 0     | 18    | 0     | 0     | 8     | 0     | 0     |
| Algae, . . . . .              | 116   | 34    | 54    | 58    | 42    | 31    | 5     |
| Chlorococcus, . . . . .       | 0     | 0     | 40    | 0     | 0     | 1     | 0     |
| Cosmarium, . . . . .          | 1     | 0     | 2     | 0     | 1     | 0     | 0     |
| Protococcus, . . . . .        | 115   | 31    | 1     | 0     | 0     | 0     | 0     |
| Raphidium, . . . . .          | 0     | 0     | 6     | 56    | 35    | 0     | 5     |
| Scenedesmus, . . . . .        | 0     | 0     | 4     | 0     | 0     | 0     | 0     |
| Staurostrum, . . . . .        | 0     | 2     | 0     | 1     | 0     | 1     | 0     |
| Staurogenia, . . . . .        | 0     | 1     | 1     | 0     | 6     | 25    | 0     |
| Zoospores, . . . . .          | 0     | 0     | 0     | 1     | 0     | 4     | 0     |
| Fungi, Crenothrix, . . . . .  | 0     | 6     | 0     | 0     | 0     | 0     | 1     |

## WORCESTER.

*Microscopical Examination of Water from Bottomly Pond, Paxton—Concluded.*

[Number of organisms per cubic centimeter.]

|                                          | 1895.      |           |            |            |            |            |           |
|------------------------------------------|------------|-----------|------------|------------|------------|------------|-----------|
|                                          | June.      | July.     | Aug.       | Sept.      | Oct.       | Nov.       | Dec.      |
| <b>ANIMALS.</b>                          |            |           |            |            |            |            |           |
| <b>Infusoria, . . . . .</b>              | <b>4</b>   | <b>1</b>  | <b>1</b>   | <b>7</b>   | <b>4</b>   | <b>17</b>  | <b>41</b> |
| Codonella, . . . . .                     | 0          | 0         | 0          | 0          | 0          | 3          | 0         |
| Dinobryon, . . . . .                     | 0          | 0         | 0          | 0          | 0          | 0          | 14        |
| Dinobryon cases, . . . . .               | 0          | 0         | 0          | 7          | 0          | 2          | 0         |
| Mallomonas, . . . . .                    | 1          | 0         | 0          | 0          | 0          | 0          | 0         |
| Monas, . . . . .                         | 0          | 0         | 1          | 0          | 0          | 0          | 0         |
| Peridinium, . . . . .                    | 3          | 0         | 0          | 0          | 1          | 1          | 2         |
| Trachelomonas, . . . . .                 | 0          | 1         | 0          | 0          | 3          | 0          | 0         |
| Uroglena, . . . . .                      | 0          | 0         | 0          | 0          | 0          | 11         | 25        |
| <b>Vermes, Anura, . . . . .</b>          | <b>0</b>   | <b>0</b>  | <b>0</b>   | <b>0</b>   | <b>0</b>   | <b>1</b>   | <b>0</b>  |
| <b>Miscellaneous, Zoöglæa, . . . . .</b> | <b>0</b>   | <b>0</b>  | <b>0</b>   | <b>0</b>   | <b>60</b>  | <b>8</b>   | <b>20</b> |
| <b>TOTAL, . . . . .</b>                  | <b>148</b> | <b>83</b> | <b>416</b> | <b>845</b> | <b>158</b> | <b>156</b> | <b>99</b> |

*Chemical Examination of Water from Arnold Reservoir on Kettle Brook, Paxton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                   |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |  |
|---------|---------------------|---------------------|-------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|--|
|         |                     | Turbidity.          | Sediment.         | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |  |
|         |                     |                     |                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |  |
| 1895.   |                     |                     |                   |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |  |
| 14550   | June 23             | Distinct.           | Cons.             | 1.60   | 5.50                            | 3.50                 | .0016    | .0412       | .0324      | .0088           | .22       | .0070          | .0000     | 1.9250           | 1.3       |  |
| 14660   | July 22             | Slight.             | Cons.             | 1.90   | 5.75                            | 3.65                 | .0092    | .0570       | .0548      | .0022           | .23       | .0020          | .0002     | 1.6500           | 1.8       |  |
| 14862   | Aug. 19             | Distinct,<br>green. | Slight,<br>green. | 2.00   | 3.45                            | 2.10                 | .0060    | .0588       | .0500      | .0088           | .20       | .0090          | .0001     | 1.7160           | 1.3       |  |
| 15177   | Sept. 16            | Slight.             | Cons.             | 1.80   | 6.20                            | 3.60                 | .0112    | .0570       | .0494      | .0076           | .28       | .0030          | .0003     | 1.6263           | 1.6       |  |
| 15363   | Oct. 14             | Slight.             | Slight.           | 1.70   | 4.90                            | 3.00                 | .0366    | .0504       | .0488      | .0016           | .24       | .0100          | .0001     | 1.5444           | 0.9       |  |
| 15562   | Nov. 17             | Slight.             | Slight.           | 1.90   | 4.85                            | 3.15                 | .0395    | .0396       | .0360      | .0036           | .20       | .0070          | .0002     | 1.3923           | 0.8       |  |
| Av.     | .....               | .....               | .....             | 1.82   | 5.11                            | 3.17                 | .0173    | .0506       | .0452      | .0054           | .23       | .0048          | .0001     | 1.6423           | 1.3       |  |

Odor, distinctly vegetable. — The samples were collected from the reservoir near the dam, 1 foot beneath the surface.

## WORCESTER.

*Microscopical Examination of Water from Arnold Reservoir on Kettle Brook, Paxton.*

[Number of organisms per cubic centimeter.]

|                                   | 1895  |       |       |       |       |       |
|-----------------------------------|-------|-------|-------|-------|-------|-------|
|                                   | June. | July. | Aug.  | Sept. | Oct.  | Nov.  |
| Day of examination, . . . . .     | 29    | 28    | 20    | 17    | 17    | 21    |
| Number of sample, . . . . .       | 14550 | 14600 | 14862 | 15177 | 15363 | 15662 |
| <b>PLANTS.</b>                    |       |       |       |       |       |       |
| Diatomaceæ, . . . . .             | 28    | 28    | 57    | 28    | 4     | 16    |
| Asterionella, . . . . .           | 0     | 0     | 0     | 2     | 0     | 4     |
| Cyclotella, . . . . .             | 0     | 20    | 28    | 0     | 0     | 4     |
| Diatoma, . . . . .                | 0     | 0     | 0     | 5     | 0     | 0     |
| Navicula, . . . . .               | 0     | 0     | 1     | 3     | 1     | 0     |
| Surirella, . . . . .              | 0     | 0     | 0     | 3     | 0     | 0     |
| Synedra, . . . . .                | 28    | 0     | 28    | 14    | 3     | 6     |
| Tabellaria, . . . . .             | 0     | 6     | 0     | 1     | 0     | 2     |
| Cyanophyceæ, . . . . .            | 8     | 32    | 48    | 0     | 0     | 0     |
| Chroococcus, . . . . .            | 0     | 0     | 6     | 0     | 0     | 0     |
| Microcystis, . . . . .            | 0     | 0     | 40    | 0     | 0     | 0     |
| Oscillaria, . . . . .             | 0     | 32    | 0     | 0     | 0     | 0     |
| Algæ, . . . . .                   | 662   | 81    | 1,601 | 136   | 40    | 0     |
| Arthrodesmus, . . . . .           | 0     | 0     | 3     | 0     | 0     | 0     |
| Chlorococcus, . . . . .           | 0     | 0     | 140   | 0     | 0     | 0     |
| Cosmarium, . . . . .              | 1     | 0     | 0     | 0     | 0     | 0     |
| Eudorina, . . . . .               | 0     | 0     | 3     | 0     | 0     | 0     |
| Glœocapsa, . . . . .              | 40    | 1     | 48    | 2     | 0     | 0     |
| Pandorina, . . . . .              | 0     | 0     | 11    | 0     | 0     | 0     |
| Protooccus, . . . . .             | 620   | 24    | 1,366 | 76    | 36    | 0     |
| Raphidium, . . . . .              | 1     | 0     | 20    | 24    | 0     | 0     |
| Scenedesmus, . . . . .            | 0     | 0     | 14    | 5     | 1     | 0     |
| Staurostrum, . . . . .            | 0     | 26    | 6     | 2     | 0     | 0     |
| Staurogenia, . . . . .            | 0     | 0     | 0     | 26    | 4     | 0     |
| Fungi, Crenothrix, . . . . .      | 40    | 56    | 13    | 4     | 24    | 4     |
| <b>ANIMALS.</b>                   |       |       |       |       |       |       |
| Infusoria, . . . . .              | 0     | 0     | 688   | 18    | 2     | 2     |
| Dinobryon, . . . . .              | 0     | 0     | 244   | 13    | 0     | 0     |
| Dinobryon cases, . . . . .        | 0     | 0     | 216   | 0     | 0     | 0     |
| Peridinium, . . . . .             | 0     | 0     | 44    | 2     | 1     | 2     |
| Phacus, . . . . .                 | 0     | 0     | 0     | 1     | 1     | 0     |
| Trachelomonas, . . . . .          | 0     | 0     | 84    | 1     | 0     | 0     |
| Vorticella, . . . . .             | 0     | 0     | 0     | 1     | 0     | 0     |
| Vermes, . . . . .                 | 0     | 0     | 11    | 6     | 1     | 0     |
| Anurea, . . . . .                 | 0     | 0     | 0     | 1     | 1     | 0     |
| Polyarthra, . . . . .             | 0     | 0     | 4     | 0     | 0     | 0     |
| Rotatorian ova, . . . . .         | 0     | 0     | 6     | 5     | 0     | 0     |
| Rotifer, . . . . .                | 0     | 0     | 1     | 0     | 0     | 0     |
| Crustacea, Daphnia, . . . . .     | .02   | .02   | 0     | 0     | 0     | 0     |
| Miscellaneous, Zoöglœa, . . . . . | 0     | 0     | 40    | 4     | 3     | 12    |
| TOTAL, . . . . .                  | 730   | 175   | 2,456 | 195   | 74    | 34    |



**WORCESTER.***Record of Height of Water in Leicester and Holden Storage Reservoirs on the First of Each Month in 1895.*

NOTE — Leicester Reservoir, height of railway, 37.40 feet; Holden Reservoir, height of railway, 30.10 feet.

| DATE.            | HEIGHT OF WATER. |              | DATE.            | HEIGHT OF WATER. |              |
|------------------|------------------|--------------|------------------|------------------|--------------|
|                  | Leicester.       | Holden.      |                  | Leicester.       | Holden.      |
| <b>1895.</b>     | <b>Feet.</b>     | <b>Feet.</b> | <b>1895.</b>     | <b>Feet.</b>     | <b>Feet.</b> |
| Jan. 1, . . . .  | 12.10            | 18.30        | July 1, . . . .  | 32.10            | 30.33        |
| Feb. 1, . . . .  | 21.87            | 21.65        | Aug. 1, . . . .  | 30.80            | 29.25        |
| March 1, . . . . | 20.90            | 20.78        | Sept. 1, . . . . | 28.88            | 27.40        |
| April 1, . . . . | 27.05            | 27.30        | Oct. 1, . . . .  | 25.87            | 25.25        |
| May 1, . . . .   | 33.55            | 30.98        | Nov. 1, . . . .  | 30.00            | 30.00        |
| June 1, . . . .  | 33.30            | 30.94        | Dec. 1, . . . .  | 35.35            | 30.25        |

**WRENTHAM.**

The advice of the State Board of Health to G. H. Bacon and others of the village of Plainville, in the town of Wrentham, relative to taking the water of the Ten Mile River as a source of public water supply for the village, may be found on page 58 of this volume.

The advice of the State Board of Health to the town of North Attleborough relative to taking water from Ten Mile River for a supply of the town of North Attleborough and the village of Plainville may be found on page 35 of the annual report for 1894, and analyses of water from this source may be found on page 268 of the same volume.

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## EXAMINATION OF RIVERS.

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## EXAMINATION OF RIVERS.

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Regular monthly examinations have been made during the year 1895 of the waters of the Blackstone, Deerfield, Hoosac, Housatonic, Merrimack, Nashua, Neponset, Saugus, Taunton and Ware rivers, and occasional examinations of other rivers in the State. A special examination of the Blackstone River, similar to that made in 1891, was made during the week of September 4-11. A special examination of the Neponset River was made in the drier portion of the year, in connection with investigations of the sanitary condition of the river and the Fowl Meadows, made under direction of chapter 83 of the Resolves of 1895. Examinations were also made of the Charles River at Milford and a small tidal stream known as Crane's River at Danvers, in consequence of complaints as to their sanitary condition.

Most of the results of these examinations will be found arranged alphabetically by rivers in the following pages, but some of them are given on preceding pages, in connection with the examination of water supplies, under the names of towns where the samples were collected, as follows:—

|                                          | PAGE |
|------------------------------------------|------|
| Charles River at West Roxbury, . . . . . | 129  |
| Merrimack at Lawrence, . . . . .         | 191  |
| Merrimack at Lowell, . . . . .           | 204  |
| Neponset at Hyde Park, . . . . .         | 185  |
| Saugus at Saugus, . . . . .              | 214  |
| Taunton at Taunton, . . . . .            | 315  |

### BLACKSTONE RIVER.

The regular monthly examinations of the Blackstone River have been continued since June, 1887, and the average results for each calendar year and for the six months of each year from June to

**BLACKSTONE RIVER.**

November, as well as the detailed analyses for 1895, are given in the tables which follow.

During the year ending Nov. 30, 1895, an average of 15,700,000 gallons per day of mingled sewage and brook water, taken from the Mill Brook channel, were treated at the Worcester Precipitation Works, by the addition of about 1,030 pounds of lime per 1,000,000 gallons of sewage, the effluent and the excess of the flow of Mill Brook over the amount treated being discharged into the river. The first of the following tables is taken from the report of the superintendent of sewers of the city of Worcester for the year ending Nov. 30, 1895, and contains the monthly averages of analyses of sewage and effluent and the per cent. removed by treatment.

The special examination of the river was, as nearly as practicable, a repetition of the examination made in July, 1891, and, like that examination, was made at a time of low flow in the stream, in order that the results of the examinations might be comparable. The advice of the State Board of Health to the town of Millbury, relative to the pollution of the Blackstone River by the sewage and sewage effluent from the city of Worcester, may be found on pages 67-69 of this volume.

**WORCESTER SEWAGE PURIFICATION WORKS.***Abstract of Analyses of Sewage and Effluent.*

[Taken from the annual report of the superintendent of sewers of the city of Worcester for the year ending Nov. 30, 1895.]

[Parts per 100,000.]

| DATE OF COLLECTION.               | AMMONIA. |             |            |            | OXYGEN CONSUMED. |           | Chlorine. |
|-----------------------------------|----------|-------------|------------|------------|------------------|-----------|-----------|
|                                   | Free.    | ALBUMINOID. |            |            | Unfiltered.      | Filtered. |           |
|                                   |          | Total.      | Dissolved. | Suspended. |                  |           |           |
| Sewage, December, 1894, . . . .   | 1.400    | .650        | .278       | .272       | 5.38             | 3.16      | 6.30      |
| Effluent, December, 1894, . . . . | 1.292    | .273        | .240       | .033       | 3.02             | 2.83      | 6.29      |
| Parts removed, . . . .            | .108     | .277        | .038       | .239       | 2.36             | 0.33      | 0.01      |
| Per cent. removed, . . . .        | 7.71     | 50.36       | 13.68      | 87.94      | 43.86            | 10.44     | 0.16      |
| Sewage, January, 1895, . . . .    | 1.186    | .471        | .254       | .217       | 5.23             | 3.21      | 6.38      |
| Effluent, January, 1895, . . . .  | 1.001    | .250        | .229       | .021       | 2.85             | 2.65      | 6.28      |
| Parts removed, . . . .            | .185     | .221        | .025       | .196       | 2.38             | 0.56      | 0.10      |
| Per cent. removed, . . . .        | 15.60    | 46.92       | 9.84       | 90.33      | 45.51            | 17.45     | 1.57      |
| Sewage, February, 1895, . . . .   | 1.378    | .615        | .310       | .305       | 5.60             | 3.46      | 7.27      |
| Effluent, February, 1895, . . . . | 1.158    | .296        | .274       | .022       | 3.11             | 2.91      | 7.27      |
| Parts removed, . . . .            | .220     | .319        | .036       | .283       | 2.49             | 0.55      | 0.00      |
| Per cent. removed, . . . .        | 15.96    | 51.87       | 11.61      | 92.79      | 44.46            | 15.90     | 0.00      |

## BLACKSTONE RIVER.

WORCESTER SEWAGE PURIFICATION WORKS — *Concluded.*

[Parts per 100,000.]

| DATE OF COLLECTION.                              | AMMONIA. |             |            |            | OXYGEN CONSUMED. |           | Chlorine. |
|--------------------------------------------------|----------|-------------|------------|------------|------------------|-----------|-----------|
|                                                  | Free.    | ALBUMINOID. |            |            | Unfiltered.      | Filtered. |           |
|                                                  |          | Total.      | Dissolved. | Suspended. |                  |           |           |
| Sewage, March, 1895, . . . . .                   | .731     | .353        | .178       | .175       | 3.76             | 2.20      | 4.33      |
| Effluent, March, 1895, . . . . .                 | .644     | .182        | .169       | .013       | 1.89             | 1.77      | 4.37      |
| Parts removed, . . . . .                         | .087     | .171        | .009       | .162       | 1.87             | 0.43      | - 0.02    |
| Per cent. removed, . . . . .                     | 11.91    | 48.44       | 5.05       | 92.58      | 49.73            | 19.54     | -0.46     |
| Sewage, April, 1895, . . . . .                   | .730     | .332        | .173       | .159       | 3.70             | 2.23      | 4.32      |
| Effluent, April, 1895, . . . . .                 | .630     | .185        | .172       | .013       | 1.98             | 1.81      | 4.30      |
| Parts removed, . . . . .                         | .100     | .147        | .001       | .146       | 1.72             | 0.42      | 0.02      |
| Per cent. removed, . . . . .                     | 13.70    | 44.28       | .58        | 89.74      | 46.48            | 18.83     | 0.46      |
| Sewage, May, 1895, . . . . .                     | 1.218    | .603        | .256       | .347       | 5.59             | 3.16      | 6.36      |
| Effluent, May, 1895, . . . . .                   | 1.071    | .285        | .265       | .020       | 2.68             | 2.48      | 6.34      |
| Parts removed, . . . . .                         | .147     | .318        | -0.009     | .327       | 2.91             | 0.68      | 0.02      |
| Per cent. removed, . . . . .                     | 12.07    | 52.73       | -3.52      | 94.23      | 50.27            | 21.52     | 0.31      |
| Sewage, June, 1895, . . . . .                    | 1.346    | .607        | .262       | .345       | 6.04             | 2.70      | 6.61      |
| Effluent, June, 1895, . . . . .                  | 1.223    | .291        | .261       | .030       | 2.42             | 2.20      | 6.66      |
| Parts removed, . . . . .                         | .123     | .316        | .001       | .315       | 3.62             | 0.50      | - 0.05    |
| Per cent. removed, . . . . .                     | 9.14     | 52.06       | 0.38       | 91.31      | 59.94            | 18.52     | -0.76     |
| Sewage, July, 1895, . . . . .                    | 1.432    | .604        | .285       | .319       | 7.10             | 3.25      | 6.90      |
| Effluent, July, 1895, . . . . .                  | 1.210    | .272        | .239       | .033       | 2.57             | 2.44      | 6.73      |
| Parts removed, . . . . .                         | .222     | .332        | .046       | .286       | 4.53             | 0.81      | 0.17      |
| Per cent. removed, . . . . .                     | 15.51    | 54.96       | 16.14      | 89.66      | 63.80            | 24.92     | 2.46      |
| Sewage, August, 1895, . . . . .                  | 1.240    | .575        | .267       | .308       | 5.96             | 3.28      | 6.50      |
| Effluent, August, 1895, . . . . .                | 1.069    | .272        | .245       | .027       | 2.18             | 2.18      | 6.26      |
| Parts removed, . . . . .                         | .171     | .303        | .022       | .281       | 3.78             | 1.10      | 0.24      |
| Per cent. removed, . . . . .                     | 10.56    | 52.69       | 8.24       | 91.22      | 63.43            | 33.54     | 3.69      |
| Sewage, September, 1895, . . . . .               | 1.500    | .718        | .333       | .385       | 6.23             | 3.28      | 7.09      |
| Effluent, September, 1895, . . . . .             | 1.270    | .300        | .280       | .020       | 2.25             | 2.25      | 6.77      |
| Parts removed, . . . . .                         | .230     | .418        | .053       | .365       | 3.98             | 1.03      | 0.32      |
| Per cent. removed, . . . . .                     | 15.33    | 58.22       | 15.92      | 94.79      | 63.72            | 31.39     | 4.51      |
| Sewage, October, 1895, . . . . .                 | 1.165    | .487        | .222       | .265       | 5.00             | 2.88      | 5.80      |
| Effluent, October, 1895, . . . . .               | .968     | .246        | .209       | .037       | 2.13             | 2.02      | 5.82      |
| Parts removed, . . . . .                         | .197     | .241        | .013       | .228       | 2.87             | 0.86      | -0.02     |
| Per cent. removed, . . . . .                     | 16.90    | 49.49       | 5.86       | 86.04      | 57.40            | 29.86     | -0.34     |
| Sewage, November, 1895, . . . . .                | .590     | .306        | .166       | .140       | 3.59             | 2.11      | 3.87      |
| Effluent, November, 1895, . . . . .              | .564     | .171        | .154       | .017       | 1.75             | 1.67      | 3.90      |
| Parts removed, . . . . .                         | .026     | .135        | .012       | .123       | 1.84             | 0.44      | -0.03     |
| Per cent. removed, . . . . .                     | 4.41     | 44.12       | 7.23       | 87.86      | 51.25            | 20.85     | -0.77     |
| Sewage for year ending Dec. 1, 1895, . . . . .   | 1.160    | .518        | .249       | .270       | 5.27             | 2.91      | 5.98      |
| Effluent for year ending Dec. 1, 1895, . . . . . | 1.008    | .252        | .228       | .024       | 2.40             | 2.27      | 5.92      |
| Parts removed, . . . . .                         | .151     | .2665       | .021       | .246       | 2.86             | 0.64      | 0.063     |
| Per cent. removed, . . . . .                     | 13.02    | 51.63       | 8.43       | 91.11      | 54.35            | 21.99     | 1.05      |

NOTE. — Monthly averages are made from daily analyses of sewage and effluent. The daily sewage samples consist of forty-eight portions taken half hourly. Sewage samples are taken as nearly as possible in proportion to the amount of sewage being received at the time of sampling. Effluent samples consist of twenty-four portions taken hourly.

**BLACKSTONE RIVER.**

**AVERAGES OF CHEMICAL ANALYSES OF WATER FROM THE BLACKSTONE RIVER  
FOR THE YEARS 1888 TO 1895, INCLUSIVE.**

*Blackstone River between Mill Brook Channel and the Sewage Precipitation Works.*

[Parts per 100,000.]

| YEAR.           | Color. | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Hardness. |
|-----------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|-----------|
|                 |        | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |           |
|                 |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |           |
| 1888, . . . . . | 0.64   | -                               | -                    | .2112    | .1040       | -          | -               | 1.21      | .0370          | .0029     | -         |
| 1889, . . . . . | 0.76   | -                               | -                    | .2841    | .1198       | .0629      | .0569           | 1.06      | .0235          | .0024     | -         |
| 1890, . . . . . | 0.82   | -                               | -                    | .1800    | .1024       | .0649      | .0475           | 1.03      | .0367          | .0014     | -         |
| 1891, . . . . . | 0.80   | 13.54                           | 4.00                 | .3340    | .1563       | .0840      | .0723           | 1.73      | .0333          | .0032     | 4.6       |
| 1892, . . . . . | 0.71   | 16.28                           | 4.85                 | .2580    | .1262       | .0627      | .0635           | 1.84      | .0312          | .0061     | 4.9       |
| 1893, . . . . . | 0.68   | 17.95                           | 4.88                 | .1429    | .0803       | .0325      | .0277           | 1.04      | .0180          | .0012     | 4.5       |
| 1894, . . . . . | 0.86   | 17.17                           | 5.58                 | .0739    | .0670       | .0304      | .0266           | 0.88      | .0195          | .0006     | 3.7       |
| 1895, . . . . . | 0.84   | 13.40                           | 4.02                 | .0607    | .0374       | .0229      | .0145           | 0.86      | .0175          | .0007     | 2.9       |

*Blackstone River below Sewage Precipitation Works.*

|                 |      |       |      |       |       |       |       |      |       |       |     |
|-----------------|------|-------|------|-------|-------|-------|-------|------|-------|-------|-----|
| 1888, . . . . . | 0.64 | -     | -    | .2112 | .1040 | -     | -     | 1.21 | .0370 | .0029 | -   |
| 1889, . . . . . | 0.76 | -     | -    | .2841 | .1198 | .0629 | .0569 | 1.06 | .0235 | .0024 | -   |
| 1890, . . . . . | 0.74 | -     | -    | .2253 | .1177 | .0581 | .0596 | 1.26 | .0381 | .0016 | -   |
| 1891, . . . . . | 0.80 | 16.02 | 4.52 | .4080 | .1303 | .0695 | .0608 | 1.91 | .0358 | .0031 | 4.6 |
| 1892, . . . . . | 0.53 | 19.35 | 5.29 | .3633 | .1442 | .0737 | .0705 | 2.21 | .0278 | .0033 | 7.2 |
| 1893, . . . . . | 0.74 | 25.65 | 6.54 | .8757 | .1447 | .0864 | .0583 | 1.98 | .0369 | .0070 | 7.4 |
| 1894, . . . . . | 0.60 | 25.75 | 6.61 | .4225 | .1309 | .0946 | .0363 | 2.13 | .0316 | .0047 | 7.9 |
| 1895, . . . . . | 0.79 | 19.14 | 4.78 | .2298 | .0840 | .0573 | .0267 | 1.52 | .0347 | .0040 | 5.8 |

*Blackstone River at Uzbridge.*

|                 |      |       |      |       |       |       |       |      |       |       |     |
|-----------------|------|-------|------|-------|-------|-------|-------|------|-------|-------|-----|
| 1888, . . . . . | 0.45 | -     | -    | .0979 | .0284 | -     | -     | 0.61 | .0322 | .0008 | -   |
| 1889, . . . . . | 0.28 | -     | -    | .0992 | .0300 | .0191 | .0109 | 0.60 | .0253 | .0009 | -   |
| 1890, . . . . . | 0.25 | -     | -    | .1168 | .0214 | .0152 | .0062 | 0.66 | .0272 | .0006 | -   |
| 1891, . . . . . | 0.27 | 8.32  | 1.94 | .1647 | .0272 | .0197 | .0075 | 0.77 | .0396 | .0008 | 2.8 |
| 1892, . . . . . | 0.21 | 8.59  | 1.90 | .2113 | .0222 | .0153 | .0069 | 0.82 | .0326 | .0007 | 2.8 |
| 1893, . . . . . | 0.40 | 9.45  | 1.91 | .1603 | .0256 | .0167 | .0089 | 1.00 | .0424 | .0029 | 3.2 |
| 1894, . . . . . | 0.51 | 10.80 | 1.97 | .1372 | .0242 | .0187 | .0055 | 1.22 | .0400 | .0032 | 4.0 |
| 1895, . . . . . | 0.64 | 10.66 | 2.44 | .1081 | .0315 | .0243 | .0072 | 1.05 | .0439 | .0037 | 3.9 |

*Blackstone River at Millville.*

|                 |      |      |      |       |       |       |       |      |       |       |     |
|-----------------|------|------|------|-------|-------|-------|-------|------|-------|-------|-----|
| 1888, . . . . . | 0.47 | -    | -    | .0444 | .0253 | -     | -     | 0.44 | .0242 | .0005 | -   |
| 1889, . . . . . | 0.39 | -    | -    | .0450 | .0277 | .0206 | .0071 | 0.43 | .0160 | .0004 | -   |
| 1890, . . . . . | 0.34 | -    | -    | .0587 | .0211 | .0162 | .0049 | 0.46 | .0240 | .0004 | -   |
| 1891, . . . . . | 0.82 | 6.05 | 1.83 | .0807 | .0293 | .0194 | .0099 | 0.55 | .0275 | .0005 | 1.9 |
| 1892, . . . . . | 0.35 | 6.03 | 1.62 | .0896 | .0249 | .0180 | .0069 | 0.54 | .0218 | .0004 | 1.8 |
| 1893, . . . . . | 0.40 | 6.23 | 1.53 | .0899 | .0288 | .0225 | .0063 | 0.66 | .0289 | .0008 | 2.0 |
| 1894, . . . . . | 0.49 | 6.37 | 1.90 | .0528 | .0219 | .0173 | .0046 | 0.73 | .0232 | .0008 | 2.5 |
| 1895, . . . . . | 0.58 | 7.47 | 2.27 | .0501 | .0253 | .0199 | .0064 | 0.74 | .0278 | .0016 | 2.7 |

## BLACKSTONE RIVER.

AVERAGES OF CHEMICAL ANALYSES OF WATER FROM THE BLACKSTONE RIVER FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE, OF EACH YEAR FROM 1887 TO 1895.

*Blackstone River between Mill Brook Channel and the Sewage Precipitation Works.*

[Parts per 100,000.]

| MONTHS.          | Color. | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Hardness. |
|------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|-----------|
|                  |        | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |           |
|                  |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |           |
| June-Nov., 1887, | 0.91   | -                               | -                    | .2686    | .1741       | -          | -               | 1.35      | .0160          | -         | -         |
| " " 1888,        | 0.76   | -                               | -                    | .2658    | .1112       | .0657      | .0555           | 1.50      | .0382          | .0041     | -         |
| " " 1889,        | 0.86   | -                               | -                    | .3980    | .1430       | .0772      | .0658           | 1.32      | .0177          | .0026     | -         |
| " " 1890,        | 1.14   | 9.92                            | 3.03                 | .2107    | .1246       | .0673      | .0573           | 1.07      | .0250          | .0015     | 2.9       |
| " " 1891,        | 1.10   | 17.42                           | 5.59                 | .4913    | .1950       | .1127      | .0823           | 2.29      | .0192          | .0037     | 5.0       |
| " " 1892,        | 0.52   | 20.75                           | 6.30                 | .3547    | .1433       | .0708      | .0725           | 2.43      | .0227          | .0108     | 6.1       |
| " " 1893,        | 0.40   | 16.98                           | 4.55                 | .1480    | .0588       | .0240      | .0348           | 1.01      | .0115          | .0015     | 6.3       |
| " " 1894,        | 0.66   | 16.93                           | 4.76                 | .0548    | .0380       | .0236      | .0144           | 0.74      | .0115          | .0005     | 4.4       |
| " " 1895,        | 0.40   | 14.17                           | 4.50                 | .0613    | .0414       | .0243      | .0171           | 0.92      | .0163          | .0006     | 3.4       |

*Blackstone River below Sewage Precipitation Works.*

|                        |      |       |      |       |       |       |       |      |       |       |      |
|------------------------|------|-------|------|-------|-------|-------|-------|------|-------|-------|------|
| June-Nov., 1887, . . . | 0.91 | -     | -    | .2686 | .1741 | -     | -     | 1.35 | .0160 | -     | -    |
| " " 1888, . . .        | 0.76 | -     | -    | .2658 | .1112 | .0557 | .0555 | 1.50 | .0382 | .0041 | -    |
| " " 1889, . . .        | 0.86 | -     | -    | .3980 | .1430 | .0772 | .0658 | 1.32 | .0177 | .0026 | -    |
| " " 1890, . . .        | 0.97 | 11.36 | 3.10 | .2907 | .1492 | .0722 | .0770 | 1.46 | .0270 | .0018 | 3.9  |
| " " 1891, . . .        | 1.05 | 22.25 | 6.60 | .6367 | .1508 | .0883 | .0625 | 2.61 | .0233 | .0040 | 6.2  |
| " " 1892, . . .        | 0.63 | 26.80 | 7.75 | .5240 | .1810 | .0958 | .0852 | 3.13 | .0137 | .0050 | 10.3 |
| " " 1893, . . .        | 0.51 | 30.00 | 7.13 | .5680 | .1453 | .0900 | .0563 | 2.76 | .0285 | .0126 | 10.9 |
| " " 1894, . . .        | 0.40 | 29.30 | 5.86 | .6189 | .1390 | .1113 | .0277 | 2.63 | .0212 | .0071 | 10.6 |
| " " 1895, . . .        | 0.71 | 22.15 | 5.18 | .3246 | .0898 | .0597 | .0301 | 1.86 | .0267 | .0063 | 7.3  |

*Blackstone River at Uzbridge.*

|                        |      |       |      |       |       |       |       |      |       |       |     |
|------------------------|------|-------|------|-------|-------|-------|-------|------|-------|-------|-----|
| June-Nov., 1887, . . . | 0.39 | -     | -    | .1129 | .0271 | -     | -     | 0.79 | .0360 | -     | -   |
| " " 1888, . . .        | 0.38 | 6.42  | 1.52 | .1155 | .0288 | .0222 | .0066 | 0.65 | .0310 | .0007 | -   |
| " " 1889, . . .        | 0.32 | -     | -    | .1133 | .0296 | .0192 | .0104 | 0.66 | .0333 | .0009 | -   |
| " " 1890, . . .        | 0.26 | 8.80  | 2.12 | .1629 | .0231 | .0174 | .0057 | 0.79 | .0259 | .0005 | 2.9 |
| " " 1891, . . .        | 0.20 | 10.16 | 2.61 | .2280 | .0175 | .0117 | .0058 | 1.04 | .0425 | .0007 | 3.6 |
| " " 1892, . . .        | 0.13 | 9.36  | 1.88 | .2840 | .0227 | .0162 | .0065 | 0.99 | .0313 | .0007 | 3.1 |
| " " 1893, . . .        | 0.24 | 11.74 | 2.37 | .1985 | .0207 | .0140 | .0067 | 1.20 | .0623 | .0050 | 4.2 |
| " " 1894, . . .        | 0.35 | 13.07 | 2.03 | .1456 | .0243 | .0183 | .0060 | 1.57 | .0673 | .0050 | 4.9 |
| " " 1895, . . .        | 0.56 | 12.95 | 2.69 | .0908 | .0258 | .0182 | .0076 | 1.34 | .0631 | .0065 | 4.7 |

*Blackstone River at Millville.*

|                        |      |      |      |       |       |       |       |      |       |       |     |
|------------------------|------|------|------|-------|-------|-------|-------|------|-------|-------|-----|
| June-Nov., 1887, . . . | 0.31 | -    | -    | .0468 | .0220 | -     | -     | 0.51 | .0210 | -     | -   |
| " " 1888, . . .        | 0.41 | 5.22 | 1.40 | .0467 | .0296 | .0233 | .0063 | 0.50 | .0278 | .0004 | -   |
| " " 1889, . . .        | 0.38 | -    | -    | .0499 | .0273 | .0213 | .0060 | 0.45 | .0167 | .0003 | -   |
| " " 1890, . . .        | 0.26 | 6.71 | 2.24 | .0736 | .0196 | .0152 | .0044 | 0.53 | .0229 | .0003 | 2.3 |
| " " 1891, . . .        | 0.24 | 7.48 | 2.35 | .1105 | .0884 | .0234 | .0150 | 0.72 | .0398 | .0006 | 2.2 |
| " " 1892, . . .        | 0.37 | 6.70 | 1.62 | .1143 | .0294 | .0210 | .0084 | 0.63 | .0217 | .0002 | 2.0 |
| " " 1893, . . .        | 0.23 | 7.43 | 1.73 | .0677 | .0119 | .0087 | .0031 | 0.77 | .0385 | .0011 | 2.6 |
| " " 1894, . . .        | 0.47 | 8.42 | 2.16 | .0510 | .0172 | .0139 | .0033 | 0.89 | .0273 | .0012 | 2.8 |
| " " 1895, . . .        | 0.51 | 8.67 | 2.55 | .0356 | .0233 | .0180 | .0053 | 0.90 | .0383 | .0024 | 3.2 |

\* Average of five months. No sample was obtained in June.



## BLACKSTONE RIVER.

*Chemical Examination of Water from Blackstone River between*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                 |        | RESIDUE ON EVAPORATION. |            |            |                   |            |            |
|---------|---------------------|------------------|-----------------|--------|-------------------------|------------|------------|-------------------|------------|------------|
|         |                     | Turbidity.       | Sediment.       | Color. | TOTAL RESIDUE.          |            |            | LOSS ON IGNITION. |            |            |
|         |                     |                  |                 |        | Total.                  | Dissolved. | Suspended. | Total.            | Dissolved. | Suspended. |
| 1893.   |                     |                  |                 |        |                         |            |            |                   |            |            |
| 1       | 13671 Jan. 15       | Distinct, milky. | Cons., dark.    | 1.40   | 9.60                    | 8.20       | 1.40       | 3.20              | 1.80       | 1.40       |
| 2       | 13870 Feb. 20       | Decided.         | Heavy, brown.   | 0.48   | 24.00                   | 16.20      | 7.80       | 7.40              | 4.20       | 3.20       |
| 3       | 14006 Mar. 19       | Decided.         | Cons.           | 1.50   | 12.80                   | 10.00      | 2.80       | 2.40              | 1.80       | 0.60       |
| 4       | 14157 Apr. 16       | Distinct.        | Cons.           | 1.30   | 9.00                    | 4.80       | 4.20       | 2.40              | 2.20       | 0.20       |
| 5       | 14343 May 21        | Decided.         | Cons., rusty.   | 1.30   | 11.20                   | 7.60       | 3.60       | 2.60              | 2.40       | 0.20       |
| 6       | 14500 June 19       | Decided, milky.  | Heavy, rusty.   | 0.18   | 14.00                   | 9.60       | 4.40       | 4.80              | 3.80       | 1.00       |
| 7       | 14686 July 23       | Decided.         | Heavy, rusty.   | 0.10   | 15.40                   | 10.40      | 5.00       | 4.00              | 1.70       | 2.30       |
| 8       | 14878 Aug. 20       | Distinct, milky. | Heavy, rusty.   | 0.08   | 15.20                   | 9.60       | 5.60       | 5.40              | 3.40       | 2.00       |
| 9       | 15190 Sept. 17      | Distinct, rusty. | Heavy, rusty.   | 0.08   | 17.60                   | 14.80      | 2.80       | 3.80              | 2.60       | 1.20       |
| 10      | 15376 Oct. 15       | Decided.         | Cons.           | 1.25   | 11.20                   | 9.60       | 1.60       | 4.40              | 4.00       | 0.40       |
| 11      | 15572 Nov. 19       | Decided.         | Cons.           | 1.25   | 11.60                   | 9.80       | 1.80       | 4.60              | 3.40       | 1.20       |
| 12      | 15757 Dec. 17       | Distinct, milky. | Slight, earthy. | 1.20   | 9.20                    | 7.40       | 1.80       | 3.20              | 2.80       | 0.40       |
| 13      | Av. ....            | .....            | .....           | 0.84   | 13.40                   | 9.83       | 3.57       | 4.02              | 2.84       | 1.18       |

Odor, disagreeable or offensive. — The samples were collected from the river, about 200 feet below the iron bridge. Nos. 13870 and 14686 were collected on Wednesday, and the other samples on Tuesday. The samples were collected at various hours between 8.10 A.M. and 1.30 P.M.

*Chemical Examination of Water from Blackstone*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |               |        | RESIDUE ON EVAPORATION. |            |            |                   |            |            |
|---------|---------------------|------------------|---------------|--------|-------------------------|------------|------------|-------------------|------------|------------|
|         |                     | Turbidity.       | Sediment.     | Color. | TOTAL RESIDUE.          |            |            | LOSS ON IGNITION. |            |            |
|         |                     |                  |               |        | Total.                  | Dissolved. | Suspended. | Total.            | Dissolved. | Suspended. |
| 1895.   |                     |                  |               |        |                         |            |            |                   |            |            |
| 1       | 13672 Jan. 15       | Distinct, milky. | Cons., dark.  | 1.20   | 15.00                   | 13.00      | 2.00       | 2.80              | 2.40       | 0.40       |
| 2       | 13871 Feb. 20       | Decided.         | Heavy, brown. | 1.00   | 21.40                   | 14.60      | 6.80       | 3.80              | 3.40       | 0.40       |
| 3       | 14007 Mar. 19       | Decided.         | Heavy, dark.  | 0.25   | 18.40                   | 11.40      | 7.00       | 5.60              | 2.40       | 3.20       |
| 4       | 14158 Apr. 16       | Distinct.        | Cons.         | 1.00   | 9.60                    | 6.60       | 3.00       | 3.80              | 2.60       | 1.20       |
| 5       | 14344 May 21        | Decided.         | Heavy, rusty. | 0.90   | 17.00                   | 12.80      | 4.20       | 5.60              | 4.60       | 1.00       |
| 6       | 14501 June 19       | Distinct, milky. | Heavy, brown. | 0.22   | 24.40                   | 18.00      | 6.40       | 6.40              | 3.60       | 2.80       |
| 7       | 14687 July 23       | Decided.         | Cons., brown. | 0.66   | 24.40                   | 21.40      | 3.00       | 4.50              | 3.70       | 0.80       |
| 8       | 14879 Aug. 20       | Decided, rusty.  | Heavy, rusty. | 0.40   | 19.50                   | 16.50      | 3.00       | 5.40              | 4.10       | 1.30       |
| 9       | 15191 Sept. 17      | Decided, rusty.  | Heavy, rusty. | 0.20   | 38.00                   | 35.40      | 2.60       | 6.60              | 6.20       | 0.40       |
| 10      | 15377 Oct. 15       | Decided.         | Cons.         | 1.50   | 15.00                   | 12.60      | 2.40       | 4.60              | 3.40       | 1.20       |
| 11      | 15573 Nov. 19       | Decided.         | Cons.         | 1.25   | 11.00                   | 9.60       | 2.00       | 3.60              | 2.20       | 1.40       |
| 12      | 15758 Dec. 17       | Distinct, milky. | Cons., brown. | 0.90   | 15.40                   | 13.20      | 2.20       | 4.60              | 4.20       | 0.40       |
| 13      | Av. ....            | .....            | .....         | 0.79   | 19.14                   | 15.42      | 3.72       | 4.78              | 3.57       | 1.21       |

Odor, disagreeable, generally offensive. — The samples were collected from the river, above Millbury and below the point where the effluent from the Worcester Sewage Precipitation Works enters the river. Nos. 13871 and 14687 were collected on Wednesday, and the remaining samples on Tuesday. The samples were collected at various hours between 8.20 A.M. and 1.40 P.M.

## BLACKSTONE RIVER.

*Mill Brook Channel and the Worcester Sewage Precipitation Works.*

[Parts per 100,000.]

| AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | IRON.       |           | Hardness. |    |
|----------|-------------|------------|------------|-----------|-------------|-----------|-------------|-----------|-----------|----|
| Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. | Unfiltered. | Filtered. |           |    |
|          | Total.      | Dissolved. | Suspended. |           |             |           |             |           |           |    |
| .0192    | .0284       | .0240      | .0044      | 1.00      | .0200       | .0006     | 0.3000      | 0.2200    | 1.9       | 1  |
| .0320    | .0350       | .0140      | .0210      | 0.81      | .0000       | .0020     | 1.6800      | 1.1600    | -         | 2  |
| .0980    | .0430       | .0300      | .0130      | 0.78      | .0230       | .0010     | 0.8200      | 0.6400    | 3.5       | 3  |
| .0608    | .0400       | .0252      | .0148      | 0.76      | .0370       | .0007     | 0.5760      | 0.4300    | 2.3       | 4  |
| .0112    | .0320       | .0208      | .0112      | 0.52      | .0070       | .0002     | 0.4500      | 0.2000    | 1.7       | 5  |
| .0816    | .0488       | .0172      | .0316      | 0.59      | .0080       | .0006     | 1.2200      | 0.0940    | 2.6       | 6  |
| .0720    | .0380       | .0170      | .0210      | 0.77      | .0030       | .0001     | 0.9400      | 0.0280    | 8.6       | 7  |
| .0868    | .0304       | .0172      | .0132      | 1.16      | .0070       | .0004     | 0.9000      | 0.1200    | 2.7       | 8  |
| .0960    | .0230       | .0190      | .0040      | 1.02      | .0100       | .0004     | 1.5800      | 1.5000    | 7.0       | 9  |
| .0464    | .0492       | .0416      | .0076      | 0.76      | .0400       | .0012     | 0.3100      | 0.2400    | 2.3       | 10 |
| .0650    | .0590       | .0340      | .0250      | 1.22      | .0300       | .0011     | 0.2500      | 0.2200    | 2.3       | 11 |
| .0320    | .0220       | .0160      | .0070      | 0.89      | .0250       | .0005     | 0.4900      | 0.3640    | 1.7       | 12 |
| .0507    | .0374       | .0229      | .0145      | 0.86      | .0175       | .0007     | 0.7930      | 0.4346    | 2.9       | 13 |

*Microscopical Examination.*

Not examined.

*River below the Worcester Sewage Precipitation Works.*

[Parts per 100,000.]

| AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | IRON.       |           | Hardness. |    |
|----------|-------------|------------|------------|-----------|-------------|-----------|-------------|-----------|-----------|----|
| Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. | Unfiltered. | Filtered. |           |    |
|          | Total.      | Dissolved. | Suspended. |           |             |           |             |           |           |    |
| .1560    | .0510       | .0450      | .0060      | 1.36      | .0450       | .0017     | 0.2400      | .1500     | 4.4       | 1  |
| .1536    | .0708       | .0464      | .0244      | 1.40      | .0220       | .0008     | 0.7600      | .2160     | -         | 2  |
| .1360    | .1750       | .1130      | .0620      | 1.17      | .0420       | .0015     | 0.9400      | .0600     | 3.5       | 3  |
| .0448    | .0364       | .0264      | .0100      | 0.59      | .0480       | .0010     | 0.2500      | .1640     | 2.6       | 4  |
| .1680    | .0870       | .0620      | .0250      | 1.08      | .0300       | .0025     | 0.3400      | .1080     | 5.0       | 5  |
| .3600    | .0940       | .0490      | .0460      | 1.90      | .0150       | .0200     | 0.9000      | .0440     | 7.6       | 6  |
| .4560    | .1020       | .0620      | .0400      | 2.06      | .0050       | .0000     | -           | .0900     | 9.3       | 7  |
| .1760    | .0910       | .0600      | .0310      | 1.59      | .0220       | .0040     | 0.9800      | .1400     | 6.4       | 8  |
| .7680    | .1290       | .1040      | .0250      | 3.40      | .0100       | .0105     | 1.6400      | .6700     | 15.2      | 9  |
| .1036    | .0676       | .0472      | .0204      | 1.13      | .0680       | .0018     | 0.5900      | .2700     | 3.8       | 10 |
| .0840    | .0550       | .0370      | .0180      | 1.11      | .0400       | .0013     | 0.3900      | .1300     | 2.5       | 11 |
| .1620    | .0490       | .0360      | .0130      | 1.43      | .0700       | .0025     | 0.3200      | .1800     | 4.9       | 12 |
| .2208    | .0840       | .0573      | .0267      | 1.52      | .0347       | .0040     | 0.6682      | .1768     | 5.8       | 13 |

*Microscopical Examination.*

Not examined.

**BLACKSTONE RIVER.***Chemical Examination of Water from Blackstone River at Uzbridge.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |          | Oxygen Consumed. | Hardness. |
|---------|---------------------|------------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|----------|------------------|-----------|
|         |                     | Turbidity.       | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrate.    | Nitrite. |                  |           |
|         |                     |                  |                |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |          |                  |           |
|         | 1895.               |                  |                |        |                         |                   |          |             |            |            |           |             |          |                  |           |
| 13690   | Jan. 18             | Distinct, milky. | Slight.        | 0.63   | 8.90                    | 2.50              | .1400    | .0390       | .0370      | .0020      | 0.93      | .0270       | .0012    | .5411            | 3.1       |
| 13874   | Feb. 21             | Decided.         | Cons.          | 0.60   | 12.10                   | 1.60              | .2440    | .0450       | .0430      | .0020      | 1.29      | .0180       | .0007    | .4836            | 4.6       |
| 14029   | Mar. 21             | Distinct.        | Slight.        | 0.75   | 6.90                    | 1.70              | .1040    | .0370       | .0270      | .0100      | 0.61      | .0200       | .0014    | .5214            | 2.7       |
| 14173   | Apr. 17             | Decided.         | Heavy, earthy. | 0.60   | 5.90                    | 2.00              | .0360    | .0340       | .0194      | .0146      | 0.46      | .0280       | .0007    | .5056            | 1.6       |
| 14357   | May 23              | Decided.         | Cons., rusty.  | 0.75   | 7.90                    | 2.40              | .0920    | .0220       | .0160      | .0060      | 0.80      | .0270       | .0025    | .4446            | 3.5       |
| 14721   | July 29             | Decided.         | Heavy, brown.  | 0.20   | 14.50                   | 2.25              | .0304    | .0492       | .0196      | .0296      | 1.71      | .0800       | .0125    | .4466            | 5.9       |
| 14900   | Aug. 22             | Distinct.        | Cons., rusty.  | 0.20   | 15.40                   | 3.20              | .0760    | .0110       | .0100      | .0010      | 1.70      | .1000       | .0100    | .3900            | 5.6       |
| 15220   | Sept. 19            | Slight.          | Slight.        | 0.27   | 17.80                   | 3.10              | .2080    | .0150       | .0150      | .0000      | 2.03      | .0850       | .0090    | .3822            | 6.6       |
| 15257   | Sept. 26            | Slight.          | Slight.        | 0.20   | 17.10                   | 2.70              | .1680    | .0260       | .0210      | .0050      | 1.88      | .0560       | .0065    | .3159            | 6.0       |
| 15421   | Oct. 24             | Distinct, milky. | Slight.        | 1.20   | 10.60                   | 2.40              | .1300    | .0250       | .0240      | .0010      | 0.92      | .0370       | .0015    | .6926            | 3.6       |
| 15580   | Nov. 21             | Distinct.        | Cons.          | 0.95   | 6.80                    | 2.70              | .0288    | .0232       | .0192      | .0040      | 0.42      | .0280       | .0007    | .6068            | 2.2       |
| 15776   | Dec. 19             | Distinct, milky. | V. slight.     | 0.90   | 9.70                    | 3.20              | .1200    | .0410       | .0340      | .0070      | 0.76      | .0470       | .0014    | .4697            | 3.5       |
| Av.*    |                     |                  |                | 0.64   | 10.56                   | 2.44              | .1081    | .0315       | .0243      | .0072      | 1.05      | .0439       | .0037    | .4955            | 3.9       |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

Odor, generally musty, frequently disagreeable or offensive. The iron was determined in the first five samples, the average amount being .0756. — The samples were collected from the canal leading from the upper dam of the Calumet Woolen Company to the mill, just before the water passed the screens.

*Microscopical Examination.*

The number of organisms found in these samples varied from 38 to 1034 per cubic centimeter, and averaged 401, *Zooglaea* being generally the most abundant, and averaging 354.

## BLACKSTONE RIVER.

Chemical Examination of Water from Blackstone River at Millville, Blackstone.

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|------------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.       | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                  |                |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
|         | <b>1895.</b>        |                  |                |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 13637   | Jan. 17             | Distinct, milky. | Cons., rusty.  | 0.68   | 7.70                    | 2.10              | .0840    | .0310       | .0250      | .0060      | 0.77      | .0150       | .0007     | .5016            | 2.6       |
| 13875   | Feb. 21             | Distinct.        | Slight.        | 0.62   | 7.10                    | 1.50              | .1000    | .0250       | .0150      | .0100      | 0.68      | .0130       | .0012     | .4680            | 2.5       |
| 14032   | Mar. 21             | Distinct.        | Slight.        | 0.63   | 5.60                    | 2.10              | .0640    | .0270       | .0210      | .0060      | 0.58      | .0220       | .0007     | .5056            | 2.1       |
| 14186   | Apr. 18             | Distinct.        | Cons., rusty.  | 0.60   | 4.60                    | 2.10              | .0132    | .0170       | .0132      | .0038      | 0.40      | .0130       | .0003     | .4503            | 1.4       |
| 14358   | May 23              | Decided.         | Cons., rusty.  | 0.60   | 5.40                    | 2.30              | .0400    | .0280       | .0160      | .0120      | 0.50      | .0180       | .0011     | .4902            | 2.2       |
| 14513   | June 20             | Distinct.        | Slight.        | 0.40   | 9.00                    | 2.80              | .0600    | .0200       | .0140      | .0060      | 0.86      | .0200       | .0065     | .3705            | 3.4       |
| 14728   | July 29             | Slight.          | Slight.        | 0.28   | 8.90                    | 1.60              | .0108    | .0216       | .0188      | .0028      | 1.04      | .0400       | .0013     | .3465            | 3.9       |
| 14899   | Aug. 22             | Slight, milky.   | Slight.        | 0.20   | 11.20                   | 3.70              | .0140    | .0208       | .0156      | .0052      | 1.30      | .0750       | .0025     | .3354            | 4.2       |
| 15273   | Sept. 27            | Distinct, milky. | Slight, brown. | 0.30   | 10.20                   | 2.10              | .0680    | .0276       | .0220      | .0056      | 1.20      | .0530       | .0025     | .3042            | 3.5       |
| 15425   | Oct. 24             | Distinct, milky. | Slight, brown. | 0.95   | 7.30                    | 3.00              | .0410    | .0230       | .0190      | .0040      | 0.57      | .0220       | .0008     | .7605            | 2.3       |
| 15590   | Nov. 21             | Distinct         | Cons.          | 0.95   | 5.40                    | 2.10              | .0200    | .0268       | .0188      | .0080      | 0.42      | .0200       | .0005     | .6318            | 1.8       |
| 15778   | Dec. 19             | Distinct, milky. | Slight.        | 0.70   | 7.30                    | 1.80              | .0840    | .0360       | .0290      | .0070      | 0.55      | .0230       | .0007     | .4851            | 2.5       |
| Av.     | .....               | .....            | .....          | 0.58   | 7.47                    | 2.27              | .0501    | .0253       | .0189      | .0054      | 0.74      | .0278       | .0016     | .4708            | 2.7       |

Odor, musty and frequently also disagreeable. The iron was determined in the first five samples, the average amount being .0714. — The samples were collected from the river, just above the dam in the village of Millville.

*Microscopical Examination.*

The number of organisms found in these samples varied from 131 to 909 per cubic centimeter, and averaged 398, *Zoëglæa* being generally the most abundant, and averaging 250.

## SPECIAL EXAMINATION OF THE BLACKSTONE RIVER AND WORCESTER PRECIPITATION WORKS IN SEPTEMBER, 1895.

The examination was made during the week ending Sept. 11, 1895, and was conducted as nearly as possible in the same manner as the examination made in July, 1891, described on page 267 of the report of the State Board of Health for 1891.

The method of collecting the sewage of Worcester and conveying it to the precipitation works remains the same as in 1891. Nearly all of the sewage of the city is discharged into Mill Brook, the channel

**BLACKSTONE RIVER.**

of which has practically been converted into a sewer, having an outlet into the Blackstone River at Quinsigamond Village. The main sewer leading to the precipitation works leads out of the Mill Brook channel near its lower end, and under ordinary conditions the whole flow of Mill Brook is diverted into the sewer by means of a dam, but at times a portion of the flow of the brook passes over the dam and enters the river without treatment.

In addition to the sewage of the city of Worcester, Mill Brook receives the natural drainage from a watershed of about 12.5 square miles, and its flow is consequently subject to great fluctuations. The character of the sewage of Worcester has been fully described in previous reports. Its composition is very variable, both on account of the fact that the sewage is mingled with the water of Mill Brook and on account of the large amount of manufacturing sewage which it receives, and which contains, at times, large amounts of iron salts discharged from the iron wire works in the city.

At the time of the examination in 1891 the normal capacity of the precipitation works was about 5,000,000 gallons per day, and during the examination a little over 6,000,000 gallons per day of sewage from the Mill Brook sewer was treated at the works. A much larger amount than this was conveyed to the works, but the excess was discharged untreated through a by-pass, and entered the river with the effluent. The works were enlarged in 1893, and the new works, which are said to have a capacity of 15,000,000 gallons per day, and to be capable of treating with good results a somewhat larger quantity, are thought to be of sufficient capacity to take the whole flow of Mill Brook under ordinary conditions.

The amount treated during the examination in 1895 averaged about 13,000,000 gallons per day, somewhat over twice the amount treated at the works during the previous examination, and all of the mingled sewage and brook water conveyed to the works was treated, the by-pass being closed.

The general results of the examinations of 1895 are shown in the tables which follow, while the detailed results are shown in tables beginning on page 376. For convenience in comparing the results of the examination of 1895 with the examination in 1891, the general results for the latter examination are reprinted, as far as is practicable, in the tables of general results which follow. The total

**BLACKSTONE RIVER.**

volume flowing in the various channels during each examination is given in the table on page 374. From this table it will be seen that the average flow in Mill Brook channel was somewhat greater in 1895 than in 1891, and that a very small proportion of the flow of Mill Brook was discharged into the river without treatment, as compared with the volume discharged in this way in 1891. The discharge of sewage directly into the river during the examination of 1895 was caused partly by leakage past the dam and partly by a shower which began at about 10 P.M. on the night of Monday, September 10, and caused the water in Mill Brook to overflow the dam. The total flow of the river below the precipitation works averaged 26,830,000 gallons per day in 1895, as compared with 35,840,000 gallons per day in 1891.

The amount of lime per 1,000,000 gallons used for the purification of the sewage during the week of the examination was considerably in excess of the average amount used during the year, and the purification of the sewage attained was greater than is ordinarily attained in the operation of the works. The results of the examination show that the condition of the river below the place where the effluent from the Worcester precipitation works is discharged, and in the town of Milbury, was practically the same as at the time of the special examination in 1891.

**BLACKSTONE RIVER.**

*Comparison of Analyses of Sewage and Effluent from the Worcester Precipitation Works during the Week ending July 29, 1891, and the Week ending Sept. 11, 1895.*

[Parts per 100,000.]

|                                                         | 1891.   |           |                                 | 1895.     |           |                                 |
|---------------------------------------------------------|---------|-----------|---------------------------------|-----------|-----------|---------------------------------|
|                                                         | Sewage. | Effluent. | Per Cent. Decrease or Increase. | Sewage.   | Effluent. | Per Cent. Decrease or Increase. |
| Residue on evaporation,—                                |         |           |                                 |           |           |                                 |
| Total, . . . . .                                        | 92.86   | 52.65     | 43 decrease.                    | 90.79     | 56.85     | 37 decrease.                    |
| Dissolved, . . . . .                                    | 44.13   | 46.64     | 6 increase.                     | 54.84     | 54.27     | 1 decrease.                     |
| Suspended, . . . . .                                    | 48.73   | 6.01      | 88 decrease.                    | 35.95     | 2.58      | 93 decrease.                    |
| Loss on ignition, . . . . .                             | 25.31   | 12.60     | 56 decrease.                    | 37.33     | 11.09     | 70 decrease.                    |
| Dissolved, . . . . .                                    | 13.29   | 11.28     | 15 decrease.                    | 19.11     | 9.99      | 48 decrease.                    |
| Suspended, . . . . .                                    | 15.02   | 1.32      | 91 decrease.                    | 18.22     | 1.10      | 94 decrease.                    |
| Fixed residue, . . . . .                                | 64.55   | 40.05     | 38 decrease.                    | 53.46     | 45.76     | 14 decrease.                    |
| Dissolved, . . . . .                                    | 30.84   | 35.36     | 15 increase.                    | 35.73     | 44.28     | 24 increase.                    |
| Suspended, . . . . .                                    | 33.77   | 4.69      | 86 decrease.                    | 17.73     | 1.48      | 92 decrease.                    |
| Free ammonia, . . . . .                                 | 1.2684  | 1.1829    | 7 decrease.                     | 1.3694    | 1.3268    | 3 decrease.                     |
| Albuminoid ammonia, . . . . .                           | .4509   | .1994     | 56 decrease.                    | .6397     | .2477     | 61 decrease.                    |
| Dissolved, . . . . .                                    | .1510   | .1588     | 5 increase.                     | .2452     | .1996     | 19 decrease.                    |
| Suspended, . . . . .                                    | .2999   | .0406     | 86 decrease.                    | .3945     | .0481     | 88 decrease.                    |
| Chlorine, . . . . .                                     | 5.33    | 4.77      | 11 decrease.                    | 6.34      | 6.32      | —                               |
| Nitrogen as nitrates, . . . . .                         | .0576   | .0542     | 6 decrease.                     | .0155     | .0179     | 15 increase.                    |
| Nitrogen as nitrites, . . . . .                         | .0103   | .0562     | 446 increase.                   | .0155     | .0321     | 107 increase.                   |
| Oxygen consumed,—                                       |         |           |                                 |           |           |                                 |
| Unfiltered, . . . . .                                   | 4.9126  | 1.0583    | 78 decrease.                    | 7.7654    | 2.4950    | 68 decrease.                    |
| Filtered, . . . . .                                     | 1.5728  | .8116     | 48 decrease.                    | 4.0071    | 2.2602    | 44 decrease.                    |
| Iron oxide (Fe <sub>2</sub> O <sub>3</sub> ), . . . . . | 10.75   | 0.41      | 96 decrease.                    | 10.05     | 0.18      | 98 decrease.                    |
| Lime (Ca O), . . . . .                                  | 3.33    | 12.74     | 283 increase.                   | 3.11      | 14.12     | 354 increase.                   |
| Sulphuric acid (SO <sub>3</sub> ), . . . . .            | 14.84   | 15.66     | 6 increase.                     | 17.47     | 16.54     | 5 decrease.                     |
| Bacteria per cubic centimeter, . . . . .                | 209,592 | 14,458    | 93 decrease.                    | 1,652,000 | 2,624,000 | 59 increase.                    |

NOTE.—The bacteriological examinations were made Sept. 15, 1891, and Oct. 12, 1895. The number of bacteria in the sewage, as above given, is the average of two or three determinations, made at different hours during the day.

## BLACKSTONE RIVER.

*Comparison of Analyses, made during Week ending July 29, 1891, and Week ending Sept. 11, 1895, of the Water of the Blackstone River above and below the Points where the Worcester Sewage and Sewage Effluent are discharged.*

[Parts per 100,000.]

|                                                          | 1891.                     |                                                         |                                | 1895.                     |                                                         |                                |
|----------------------------------------------------------|---------------------------|---------------------------------------------------------|--------------------------------|---------------------------|---------------------------------------------------------|--------------------------------|
|                                                          | Above Mill Brook Channel. | Between Mill Brook Channel and the Precipitation Works. | Below the Precipitation Works. | Above Mill Brook Channel. | Between Mill Brook Channel and the Precipitation Works. | Below the Precipitation Works. |
| Color, . . . . .                                         | 0.95                      | .44                                                     | .33                            | .95                       | .20                                                     | .33                            |
| Residue on evaporation, —                                |                           |                                                         |                                |                           |                                                         |                                |
| Total, . . . . .                                         | 6.94                      | 27.84                                                   | 35.89                          | 8.65                      | 23.46                                                   | 39.41                          |
| Dissolved, . . . . .                                     | —                         | 16.71                                                   | 23.69                          | —                         | 19.11                                                   | 35.31                          |
| Suspended, . . . . .                                     | —                         | 11.13                                                   | 12.20                          | —                         | 4.35                                                    | 4.10                           |
| Loss on ignition, . . . . .                              | 2.58                      | 8.37                                                    | 9.55                           | 3.47                      | 5.17                                                    | 8.17                           |
| Dissolved, . . . . .                                     | —                         | 5.19                                                    | 5.86                           | —                         | 4.16                                                    | 7.12                           |
| Suspended, . . . . .                                     | —                         | 3.18                                                    | 3.69                           | —                         | 1.01                                                    | 1.05                           |
| Fixed residue, . . . . .                                 | 4.36                      | 19.47                                                   | 26.34                          | 5.18                      | 18.29                                                   | 31.24                          |
| Dissolved, . . . . .                                     | —                         | 11.52                                                   | 17.83                          | —                         | 14.95                                                   | 28.19                          |
| Suspended, . . . . .                                     | —                         | 7.95                                                    | 8.51                           | —                         | 3.34                                                    | 3.05                           |
| Free ammonia, . . . . .                                  | .0166                     | .2699                                                   | .6233                          | .0309                     | .2627                                                   | .7574                          |
| Albuminoid ammonia, . . . . .                            | .0489                     | .1168                                                   | .1869                          | .0477                     | .0678                                                   | .2128                          |
| Dissolved, . . . . .                                     | .0318                     | .0415                                                   | .0780                          | .0392                     | .0377                                                   | .1670                          |
| Suspended, . . . . .                                     | .0171                     | .0753                                                   | .1089                          | .0085                     | .0301                                                   | .0458                          |
| Chlorine, . . . . .                                      | .27                       | 1.67                                                    | 2.48                           | .65                       | 1.23                                                    | 3.52                           |
| Nitrogen as nitrates, . . . . .                          | .0117                     | .0134                                                   | .0115                          | .0080                     | .0102                                                   | .0086                          |
| Nitrogen as nitrites, . . . . .                          | .0001                     | .0026                                                   | .0052                          | .0010                     | .0015                                                   | .0105                          |
| Oxygen consumed, —                                       |                           |                                                         |                                |                           |                                                         |                                |
| Unfiltered, . . . . .                                    | .7080                     | 1.3241                                                  | 1.7809                         | .7416                     | 1.5182                                                  | 1.8428                         |
| Filtered, . . . . .                                      | —                         | .4246                                                   | .6606                          | —                         | 1.2094                                                  | 1.6116                         |
| Iron oxide, (Fe <sub>2</sub> O <sub>3</sub> ), . . . . . | 0.36                      | 4.45                                                    | 3.52                           | 0.20                      | 3.33                                                    | 2.05                           |
| Lime (Ca O), . . . . .                                   | 0.77                      | 1.60                                                    | 4.33                           | 0.95                      | 2.41                                                    | 7.90                           |
| Sulphuric acid (SO <sub>3</sub> ), . . . . .             | 0.80                      | 5.39                                                    | 7.62                           | 1.10                      | 7.91                                                    | 11.80                          |
| Bacteria per cubic centimeter,                           | 77,750                    | 47,550                                                  | 16,650                         | 17,000                    | 2,000                                                   | 9,000                          |

NOTE. — The bacteriological examinations were made Sept. 15, 1891, and Oct. 12, 1895.



**BLACKSTONE RIVER.**

*Comparison of Analyses, made during the Week ending July 29, 1891, of the Water of the Blackstone River, from a Point just below the Precipitation Works at Worcester to Millville. This Table represents the Portion of the River where the Pollution of the Water is decreasing as the Distance from Worcester increases.*

|                                                         | 1891.                                          |                                                 |                                   |                                               |                               |
|---------------------------------------------------------|------------------------------------------------|-------------------------------------------------|-----------------------------------|-----------------------------------------------|-------------------------------|
|                                                         | Below<br>Precipitation<br>Works,<br>Worcester. | Outlet of<br>Morse's<br>Mill-pond,<br>Millbury. | Below<br>Last Dam in<br>Millbury. | Dam of<br>Calumet<br>Woolen Co.,<br>Uxbridge. | Above Dam<br>at<br>Millville. |
| Area of watershed (sq. miles), . .                      | 64.6                                           | 70.6                                            | 83.9                              | 146.9                                         | 258.1                         |
| Relative sizes of watersheds, . .                       | 1.00                                           | 1.00                                            | 1.30                              | 2.26                                          | 4.00                          |
| Color, . . . . .                                        | .33                                            | .10                                             | .10                               | .24                                           | .26                           |
| Residue on evaporation, —                               |                                                |                                                 |                                   |                                               |                               |
| Total, . . . . .                                        | 35.89                                          | 23.50                                           | 20.60                             | 11.07                                         | 7.49                          |
| Dissolved, . . . . .                                    | 23.69                                          | 23.20                                           | 16.00                             | —                                             | —                             |
| Suspended, . . . . .                                    | 12.20                                          | 5.30                                            | 4.60                              | —                                             | —                             |
| Loss on ignition, . . . . .                             | 9.55                                           | 7.50                                            | 3.80                              | 2.50                                          | 2.49                          |
| Dissolved, . . . . .                                    | 5.85                                           | 5.10                                            | 2.40                              | —                                             | —                             |
| Suspended, . . . . .                                    | 3.69                                           | 2.40                                            | 1.40                              | —                                             | —                             |
| Fixed residue, . . . . .                                | 26.34                                          | 21.00                                           | 16.80                             | 8.48                                          | 5.00                          |
| Dissolved, . . . . .                                    | 17.83                                          | 18.10                                           | 13.60                             | —                                             | —                             |
| Suspended, . . . . .                                    | 8.51                                           | 2.90                                            | 3.20                              | —                                             | —                             |
| Free ammonia, . . . . .                                 | .0233                                          | .0070                                           | .0010                             | .0206                                         | .0073                         |
| Albuminoid ammonia, . . . . .                           | .1869                                          | .1060                                           | .0690                             | .0345                                         | .0214                         |
| Dissolved, . . . . .                                    | .0780                                          | .0420                                           | .0280                             | .0271                                         | .0163                         |
| Suspended, . . . . .                                    | .1089                                          | .0640                                           | .0310                             | .0074                                         | .0061                         |
| Chlorine, . . . . .                                     | 2.48                                           | 2.85                                            | 1.71                              | 0.87                                          | 0.52                          |
| Nitrogen as nitrates, . . . . .                         | .0115                                          | .0060                                           | .0070                             | .0443                                         | .0359                         |
| Nitrogen as nitrites, . . . . .                         | .0052                                          | .0000                                           | .0001                             | .0004                                         | .0002                         |
| Oxygen consumed, —                                      |                                                |                                                 |                                   |                                               |                               |
| Unfiltered, . . . . .                                   | 1.7809                                         | 1.0455                                          | .5830                             | .1330                                         | .4270                         |
| Filtered, . . . . .                                     | .6606                                          | .5030                                           | .4705                             | .1170                                         | .2730                         |
| Iron oxide (Fe <sub>2</sub> O <sub>3</sub> ), . . . . . | 3.52                                           | 3.87                                            | 1.00                              | 0.17                                          | 0.12                          |
| Lime (Ca O), . . . . .                                  | 4.33                                           | 4.39                                            | 3.63                              | 1.99                                          | 1.12                          |
| Sulphuric acid, (SO <sub>3</sub> ), . . . . .           | 7.62                                           | 9.30                                            | 7.19                              | 3.43                                          | 1.75                          |
| Bacteria per cubic centimeter, . .                      | 16,650                                         | 84,600                                          | —                                 | —                                             | —                             |

NOTE. — The bacteriological examinations were made Sept. 15, 1891.

## BLACKSTONE RIVER.

*Comparison of Analyses, made during the Week ending Sept. 11, 1895, of the Water of the Blackstone River, from a Point just below the Precipitation Works at Worcester to Millville. This Table represents the Portion of the River where the Pollution of the Water is decreasing as the Distance from Worcester increases.*

|                                                         | 1895.                                          |                                                 |                                   |                                               |                               |
|---------------------------------------------------------|------------------------------------------------|-------------------------------------------------|-----------------------------------|-----------------------------------------------|-------------------------------|
|                                                         | Below<br>Precipitation<br>Works,<br>Worcester. | Outlet of<br>Morse's<br>Mill-pond,<br>Millbury. | Below<br>Last Dam in<br>Millbury. | Dam of<br>Calumet<br>Woolen Co.,<br>Uxbridge. | Above Dam<br>at<br>Millville. |
| Area of watershed (sq. miles), . . .                    | 64.6                                           | 70.6                                            | 83.9                              | 145.9                                         | 258.1                         |
| Relative sizes of watersheds, . . .                     | 1.00                                           | 1.09                                            | 1.30                              | 2.26                                          | 4.00                          |
| Color, . . . . .                                        | 0.33                                           | 0.80                                            | 0.27                              | 0.18                                          | 0.25                          |
| Residue on evaporation, —                               |                                                |                                                 |                                   |                                               |                               |
| Total, . . . . .                                        | 39.41                                          | 37.00                                           | 28.60                             | 16.50                                         | 10.79                         |
| Dissolved, . . . . .                                    | 35.31                                          | 34.90                                           | 25.70                             | —                                             | —                             |
| Suspended, . . . . .                                    | 4.10                                           | 2.10                                            | 2.90                              | —                                             | —                             |
| Loss on ignition, . . . . .                             | 8.17                                           | 4.70                                            | 5.60                              | 8.70                                          | 2.51                          |
| Dissolved, . . . . .                                    | 7.12                                           | 4.50                                            | 5.10                              | —                                             | —                             |
| Suspended, . . . . .                                    | 1.06                                           | 0.20                                            | 0.50                              | —                                             | —                             |
| Fixed residue, . . . . .                                | 31.24                                          | 32.30                                           | 23.00                             | 12.80                                         | 8.28                          |
| Dissolved, . . . . .                                    | 28.19                                          | 30.40                                           | 20.60                             | —                                             | —                             |
| Suspended, . . . . .                                    | 3.05                                           | 1.90                                            | 2.40                              | —                                             | —                             |
| Free ammonia, . . . . .                                 | .7874                                          | .9210                                           | .6750                             | .0947                                         | .0298                         |
| Albuminoid ammonia, . . . . .                           | .2128                                          | .1040                                           | .0740                             | .0223                                         | .0205                         |
| Dissolved, . . . . .                                    | .1670                                          | .0755                                           | .0515                             | .0181                                         | .0178                         |
| Suspended, . . . . .                                    | .0458                                          | .0285                                           | .0225                             | .0042                                         | .0027                         |
| Chlorine, . . . . .                                     | 3.52                                           | 3.57                                            | 2.82                              | 1.75                                          | 1.13                          |
| Nitrogen as nitrates, . . . . .                         | .0086                                          | .0000                                           | .0000                             | .0750                                         | .0426                         |
| Nitrogen as nitrites, . . . . .                         | .0105                                          | .0002                                           | .0102                             | .0064                                         | .0018                         |
| Oxygen consumed, —                                      |                                                |                                                 |                                   |                                               |                               |
| Unfiltered, . . . . .                                   | 1.8428                                         | 1.5870                                          | 1.2675                            | .3648                                         | .3746                         |
| Filtered, . . . . .                                     | 1.6115                                         | 1.5650                                          | 1.1505                            | —                                             | —                             |
| Iron oxide (Fe <sub>2</sub> O <sub>3</sub> ), . . . . . | 2.05                                           | 1.35                                            | 0.37                              | .07                                           | .08                           |
| Lime (Ca O), . . . . .                                  | 7.90                                           | 8.91                                            | 6.65                              | 3.44                                          | 2.06                          |
| Sulphuric acid (SO <sub>3</sub> ), . . . . .            | 11.80                                          | 13.12                                           | 9.30                              | 4.07                                          | 2.41                          |
| Bacteria per cubic centimeter, . . .                    | 9,000                                          | 94,000                                          | —                                 | —                                             | —                             |

NOTE. — The bacteriological examinations were made Oct. 12, 1895.

**BLACKSTONE RIVER.**

*Comparison of Analyses of Water from the Blackstone River in Millbury, above Singletary Brook, made in 1872, 1875, 1881, 1891 and 1895.*

[Parts per 100,000.]

|                                         | Nov. 8,<br>1872. | July,<br>1875. | Average<br>of Two<br>Analyses,<br>Aug. 30 and<br>Oct. 2, 1881. | Average<br>of Two<br>Analyses,<br>July 24 and<br>25, 1891. | Average<br>of Two<br>Analyses,<br>Sept. 6 and<br>7, 1895. |
|-----------------------------------------|------------------|----------------|----------------------------------------------------------------|------------------------------------------------------------|-----------------------------------------------------------|
| Total residue on evaporation, . . . . . | 6.20             | 8.04           | 13.15                                                          | 28.50                                                      | 37.00                                                     |
| Loss on ignition, . . . . .             | -                | -              | 3.35                                                           | 7.50                                                       | 9.70                                                      |
| Fixed residue, . . . . .                | -                | -              | 9.80                                                           | 21.00                                                      | 32.30                                                     |
| Free ammonia, . . . . .                 | .0450            | .0992          | .0793                                                          | .6070                                                      | .9210                                                     |
| Albuminoid ammonia, . . . . .           | .0400            | .0307          | .1176                                                          | .1060                                                      | .1040                                                     |
| Chlorine, . . . . .                     | 1.20             | 0.92           | 2.40                                                           | 2.85                                                       | 3.57                                                      |

NOTE.—The sample analyzed in 1872 was collected just after a heavy rain which had greatly increased the flow of the river.

*Average Daily Flow of Sewage, Sewage Effluent and River Water at Worcester during the Weeks beginning at 8 a.m., July 22, 1891, and 8 a.m., Sept. 4, 1895.*

[Cubic feet per second.]

| TWENTY-FOUR HOURS BEGIN-<br>NING AT 8 A.M.       | Sewage discharged<br>directly into River<br>at Mouth of Mill<br>Brook. | Sewage discharged<br>into River through<br>by-pass at Pre-<br>cipitation Works. | Total Sewage dis-<br>charged into River<br>without Treat-<br>ment. | Sewage Effluent dis-<br>charged into River<br>from Precipitation<br>Works. | Flow of Mill Brook<br>just above Point<br>where Sewage is<br>Diverted. | Flow of River just<br>above Mill Brook. | Flow of River be-<br>tween Mill Brook<br>and Precipitation<br>Works. | Flow of River be-<br>low Precipitation<br>Works. |
|--------------------------------------------------|------------------------------------------------------------------------|---------------------------------------------------------------------------------|--------------------------------------------------------------------|----------------------------------------------------------------------------|------------------------------------------------------------------------|-----------------------------------------|----------------------------------------------------------------------|--------------------------------------------------|
| <b>1891.</b>                                     |                                                                        |                                                                                 |                                                                    |                                                                            |                                                                        |                                         |                                                                      |                                                  |
| Wednesday, July 22, . . . . .                    | 12.00                                                                  | 1.08                                                                            | 13.98                                                              | 9.04                                                                       | 23.02                                                                  | 28.48                                   | 40.48                                                                | 51.50                                            |
| Thursday, July 23, . . . . .                     | 12.16                                                                  | 0.72                                                                            | 12.88                                                              | 9.41                                                                       | 22.29                                                                  | 41.71                                   | 53.87                                                                | 64.00                                            |
| Friday, July 24, . . . . .                       | 12.59                                                                  | 1.52                                                                            | 14.11                                                              | 9.46                                                                       | 23.57                                                                  | 51.62                                   | 64.21                                                                | 75.19                                            |
| Saturday, July 25, . . . . .                     | 10.35                                                                  | 1.22                                                                            | 11.57                                                              | 8.84                                                                       | 20.41                                                                  | 42.93                                   | 53.28                                                                | 63.34                                            |
| Sunday, July 26, . . . . .                       | 0.64                                                                   | 1.48                                                                            | 2.12                                                               | 9.20                                                                       | 11.32                                                                  | 23.25                                   | 23.89                                                                | 34.57                                            |
| Monday, July 27, . . . . .                       | 3.73                                                                   | 5.40                                                                            | 9.13                                                               | 9.69                                                                       | 18.82                                                                  | 23.63                                   | 27.36                                                                | 42.45                                            |
| Tuesday, July 28, . . . . .                      | 4.80                                                                   | 2.75                                                                            | 7.55                                                               | 9.50                                                                       | 17.08                                                                  | 39.95                                   | 44.75                                                                | 57.03                                            |
| Average, . . . . .                               | 8.04                                                                   | 2.16                                                                            | 10.20                                                              | 9.30                                                                       | 19.50                                                                  | 35.94                                   | 43.98                                                                | 55.44                                            |
| Average in million gallons per<br>day, . . . . . | 5.20                                                                   | 1.40                                                                            | 6.60                                                               | 6.01                                                                       | 12.61                                                                  | 23.23                                   | 28.43                                                                | 35.84                                            |
| <b>1895.</b>                                     |                                                                        |                                                                                 |                                                                    |                                                                            |                                                                        |                                         |                                                                      |                                                  |
| Wednesday, September 4, . . . . .                | .06                                                                    | -                                                                               | .06                                                                | 21.07                                                                      | 21.13                                                                  | 20.40                                   | 20.46                                                                | 41.53                                            |
| Thursday, September 5, . . . . .                 | .06                                                                    | -                                                                               | .06                                                                | 24.49                                                                      | 24.55                                                                  | 17.97                                   | 18.03                                                                | 42.52                                            |
| Friday, September 6, . . . . .                   | .06                                                                    | -                                                                               | .06                                                                | 20.39                                                                      | 20.45                                                                  | 20.68                                   | 20.74                                                                | 41.13                                            |
| Saturday, September 7, . . . . .                 | .06                                                                    | -                                                                               | .06                                                                | 20.41                                                                      | 20.47                                                                  | 13.22                                   | 13.28                                                                | 33.69                                            |
| Sunday, September 8, . . . . .                   | .06                                                                    | -                                                                               | .06                                                                | 11.85                                                                      | 11.89                                                                  | 3.63                                    | 3.69                                                                 | 15.52                                            |
| Monday, September 9, . . . . .                   | .40                                                                    | -                                                                               | .40                                                                | 31.98                                                                      | 32.38                                                                  | 42.47                                   | 42.87                                                                | 74.85                                            |
| Tuesday, September 10, . . . . .                 | .09                                                                    | -                                                                               | .09                                                                | 19.04                                                                      | 19.13                                                                  | 22.17                                   | 22.26                                                                | 41.30                                            |
| Average, . . . . .                               | .11                                                                    | -                                                                               | .11                                                                | 21.32                                                                      | 21.43                                                                  | 20.08                                   | 20.10                                                                | 41.51                                            |
| Average in million gallons per<br>day, . . . . . | .07                                                                    | -                                                                               | .07                                                                | 13.78                                                                      | 13.85                                                                  | 12.98                                   | 13.05                                                                | 26.83                                            |

**BLACKSTONE RIVER.**

In the following tables are given the detailed results of the examinations of 1895.

As already stated, the samples were taken in the same manner and at the same places as in 1891. In collecting the samples of sewage for chemical analysis one bottle was filled every six hours, and its contents were made up of twelve equal half-hourly collections. The samples of effluent were collected in the same way, but, as the amount of sewage being treated required about six hours for its passage through the tanks, the samples of effluent were taken six hours later than the corresponding samples of sewage. In collecting the samples from the river above and below the precipitation works three bottles were filled every twenty-four hours, each bottle being made up of two or three equal portions. From other points on the river and its tributaries only one sample per day was collected, but wherever it was practicable this sample was made up of from two to four equal portions.

## BLACKSTONE RIVER.

*Chemical Examination of Worcester Sewage,*  
[Parts per 100,000.]

| Number. |       | DATE OF —               |                    | APPEARANCE.      |                  |        | RESIDUE ON EVAPORATION. |            |            |
|---------|-------|-------------------------|--------------------|------------------|------------------|--------|-------------------------|------------|------------|
|         |       | Collection — 1895.      | Examination, 1895. | Turbidity.       | Sediment.        | Color. | TOTAL RESIDUE.          |            |            |
|         |       |                         |                    |                  |                  |        | Total.                  | Dissolved. | Suspended. |
|         |       | September.              | Sept.              |                  |                  |        |                         |            |            |
| 1       | 14972 | 4, 8 A.M. to 2 P.M.     | 5                  | Thick, black.    | Heavy, black.    | *      | 92.00                   | 62.00      | 30.00      |
| 2       | 14981 | 4, 2 P.M. to 8.30 P.M.  | 5                  | Decided, milky.  | Heavy, black.    | 0.33   | 74.00                   | 53.40      | 20.60      |
| 3       | 14995 | 4-5, 8 P.M. to 2 A.M.   | 5                  | Distinct, dark.  | Heavy, dark.     | 0.40   | 100.40                  | 76.40      | 24.00      |
| 4       | 14992 | 5, 2 A.M. to 8 A.M.     | 5                  | Decided, milky.  | Cons., yellow.   | 0.90   | 31.60                   | 20.80      | 10.80      |
| 5       | 15006 | 5, 8 A.M. to 2 P.M.     | 6                  | Thick, black.    | Heavy, black.    | *      | 98.60                   | 68.40      | 30.20      |
| 6       | 15010 | 5, 2 P.M. to 8 P.M.     | 6                  | Decided, milky.  | Heavy, black.    | 0.70   | 86.40                   | 61.60      | 24.80      |
| 7       | 15015 | 5-6, 8 P.M. to 2 A.M.   | 6                  | Distinct, milky. | Heavy, dark.     | 0.60   | 102.40                  | 75.40      | 27.00      |
| 8       | 15017 | 6, 2 A.M. to 8 A.M.     | 6                  | Decided, milky.  | Cons., brown.    | 0.15   | 33.80                   | 20.60      | 13.20      |
| 9       | 15023 | 6, 8 A.M. to 2 P.M.     | 7                  | Thick, dark.     | Heavy, black.    | 1.50   | 100.40                  | 69.20      | 31.20      |
| 10      | 15030 | 6, 2 P.M. to 8 P.M.     | 7                  | Decided, dark.   | Heavy, black.    | 0.70   | 81.60                   | 59.60      | 22.00      |
| 11      | 15034 | 6-7, 8 P.M. to 2 A.M.   | 7                  | Distinct, milky. | Heavy, dark.     | 0.70   | 89.40                   | 66.40      | 23.00      |
| 12      | 15036 | 7, 2 A.M. to 8 A.M.     | 7                  | Distinct, milky. | Cons., flocc.    | 0.25   | 53.60                   | 49.00      | 4.60       |
| 13      | 15053 | 7, 8 A.M. to 2 P.M.     | 8                  | Thick, black.    | Heavy, black.    | 1.00   | 95.20                   | 72.00      | 23.20      |
| 14      | 15054 | 7, 2 P.M. to 8 P.M.     | 8                  | Thick, black.    | Heavy, black.    | 0.90   | 87.40                   | 58.80      | 28.60      |
| 15      | 15061 | 7-8, 8 P.M. to 2 A.M.   | 8                  | Dec'd, yellow.   | Heavy, dark.     | 1.30   | 126.60                  | 103.80     | 22.80      |
| 16      | 15062 | 8, 2 A.M. to 8 A.M.     | 8                  | Dec'd, brown.    | Heavy, brown.    | 1.30   | 41.40                   | 26.60      | 14.80      |
| 17      | 15063 | 8, 8 A.M. to 2 P.M.     | 8                  | Thick, yellow.   | Heavy, black.    | 2.00   | 57.60                   | 35.20      | 22.40      |
| 18      | 15074 | 8, 2 P.M. to 8 P.M.     | 9                  | Decided, milky.  | Heavy, dark.     | 1.50   | 50.40                   | 35.40      | 15.00      |
| 19      | 15083 | 8-9, 8 P.M. to 2 A.M.   | 9                  | Decided, thick.  | Heavy, black.    | 0.80   | 67.00                   | 41.80      | 25.20      |
| 20      | 15090 | 9, 2 A.M. to 8 A.M.     | 9                  | Decided, milky.  | Cons., brown.    | 1.00   | 47.00                   | 26.20      | 20.80      |
| 21      | 15100 | 9, 8 A.M. to 2 P.M.     | 10                 | Thick, black.    | Heavy, black.    | 1.00   | 96.60                   | 64.00      | 32.60      |
| 22      | 15114 | 9, 2 P.M. to 8 P.M.     | 10                 | Distinct, gray.  | V. heavy, black. | 0.60   | 105.40                  | 61.00      | 44.40      |
| 23      | 15118 | 9-10, 8 P.M. to 2 A.M.  | 10                 | Thick, dark.     | V. heavy, dark.  | 0.38   | 181.40                  | 53.00      | 128.40     |
| 24      | 15120 | 10, 2 A.M. to 8 A.M.    | 10                 | Thick, brown.    | Cons., dark.     | 2.00   | 102.20                  | 18.60      | 83.60      |
| 25      | 15140 | 10, 8 A.M. to 2 P.M.    | 11                 | Thick, black.    | Heavy, black.    | 0.90   | 125.20                  | 96.20      | 29.00      |
| 26      | 15142 | 10, 2 P.M. to 8 P.M.    | 11                 | Distinct, milky. | V. heavy, black. | 0.50   | 91.60                   | 70.20      | 21.40      |
| 27      | 15150 | 10-11, 8 P.M. to 2 A.M. | 11                 | Decided, milky.  | Heavy, flocc.    | 0.30   | 277.20                  | 69.20      | 208.00     |
| 28      | 15152 | 11, 2 A.M. to 8 A.M.    | 11                 | Decided, milky.  | Heavy, dark.     | 0.40   | 45.60                   | 20.60      | 25.00      |
| 29      | Av... | .....                   | .....              | .....            | .....            | -      | 90.79                   | 54.84      | 35.95      |

*Averages of the Above*

|    |                                                                         |      |        |       |       |
|----|-------------------------------------------------------------------------|------|--------|-------|-------|
| 30 | For the 24 hours beginning at 8 A.M., Wednesday, September 4, . . . . . | 0.54 | 74.50  | 53.15 | 21.35 |
| 31 | For the 24 hours beginning at 8 A.M., Thursday, September 5, . . . . .  | 0.48 | 80.30  | 56.50 | 23.80 |
| 32 | For the 24 hours beginning at 8 A.M., Friday, September 6, . . . . .    | 0.79 | 81.25  | 61.05 | 20.20 |
| 33 | For the 24 hours beginning at 8 A.M., Saturday, September 7, . . . . .  | 1.13 | 87.65  | 65.30 | 22.34 |
| 34 | For the 24 hours beginning at 8 A.M., Sunday, September 8, . . . . .    | 1.20 | 55.50  | 31.65 | 20.85 |
| 35 | For the 24 hours beginning at 8 A.M., Monday, September 9, . . . . .    | 1.00 | 121.40 | 49.15 | 72.25 |
| 36 | For the 24 hours beginning at 8 A.M., Tuesday, September 10, . . . . .  | 0.53 | 134.90 | 64.05 | 70.85 |
| 37 | Average, . . . . .                                                      | -    | 90.79  | 54.84 | 35.95 |

*Averages of Samples collected at*

|    |                                                |      |        |       |       |
|----|------------------------------------------------|------|--------|-------|-------|
| 38 | For the hours from 8 A.M. to 2 P.M., . . . . . | 1.28 | 95.00  | 66.71 | 28.37 |
| 39 | For the hours from 2 P.M. to 8 P.M., . . . . . | 0.75 | 82.40  | 57.14 | 25.26 |
| 40 | For the hours from 8 P.M. to 2 A.M., . . . . . | 0.57 | 134.91 | 69.43 | 65.48 |
| 41 | For the hours from 2 A.M. to 8 A.M., . . . . . | 0.86 | 50.74  | 26.06 | 24.68 |
| 42 | Average, . . . . .                             | -    | 90.79  | 54.84 | 35.95 |

Odor, offensive. — The samples were collected from the chamber at the outlet of the sewer leading treated with chemicals. A sample was collected every six hours and was made up of twelve equal

\* Too turbid to determine.

## BLACKSTONE RIVER.

collected just above the Precipitation Works.

[Parts per 100,000.]

| RESIDUE ON EVAPORATION — CON. |            |            | AMMONIA.    |        |            |            | Chlorine. | NITROGEN AS |           | OXYGEN CONSUMED. |           | Iron Oxide (Fe <sub>2</sub> O <sub>3</sub> ). | Lime (Ca O). | Sulphuric Acid (SO <sub>3</sub> ). |    |
|-------------------------------|------------|------------|-------------|--------|------------|------------|-----------|-------------|-----------|------------------|-----------|-----------------------------------------------|--------------|------------------------------------|----|
| LOSS ON IGNITION.             |            |            | ALBUMINOID. |        |            |            |           | Nitrates.   | Nitrites. | Unfiltered.      | Filtered. |                                               |              |                                    |    |
| Total.                        | Dissolved. | Suspended. | Free.       | Total. | Dissolved. | Suspended. |           |             |           |                  |           |                                               |              |                                    |    |
| 41.00                         | 20.40      | 20.60      | 1.7540      | 0.7300 | .2120      | .5180      | 7.55      | .0050       | .0000     | 10.6260          | 5.2514    | 8.26                                          | 2.94         | 19.53                              | 1  |
| 36.60                         | 20.60      | 16.00      | 1.1540      | 0.6440 | .2280      | .4160      | 7.05      | .0150       | .0166     | 14.3374          | 4.3505    | 7.33                                          | 3.06         | 15.69                              | 2  |
| 40.20                         | 30.60      | 9.60       | 1.1160      | 0.6460 | .4040      | .2420      | 6.65      | .0080       | .0067     | 7.5075           | 4.6200    | 17.82                                         | 2.92         | 28.68                              | 3  |
| 11.40                         | 5.00       | 6.40       | 0.4560      | 0.1440 | .0520      | .0920      | 2.40      | .0900       | .0135     | 1.7564           | 1.0395    | 2.72                                          | 2.70         | 6.41                               | 4  |
| 42.60                         | 22.60      | 20.00      | 1.8560      | 0.6080 | .2480      | .3600      | 7.80      | .0000       | .0200     | 12.1680          | 6.0060    | 13.41                                         | 3.16         | 21.56                              | 5  |
| 38.20                         | 22.20      | 16.00      | 0.9880      | 0.6380 | .2420      | .3060      | 7.50      | .0100       | .0120     | 9.1280           | 5.4800    | 2.91                                          | 3.06         | 18.43                              | 6  |
| 43.80                         | 31.80      | 12.00      | 1.0480      | 0.6980 | .4420      | .2560      | 7.60      | .0090       | .0200     | 8.1900           | 5.1870    | 18.87                                         | 2.84         | 28.42                              | 7  |
| 10.40                         | 4.40       | 6.00       | 0.4780      | 0.1380 | .0620      | .0760      | 3.00      | .1000       | .0320     | 2.1840           | 1.4040    | 3.12                                          | 2.70         | 8.09                               | 8  |
| 44.80                         | 29.00      | 15.80      | 1.9520      | 0.5880 | .2140      | .3740      | 8.95      | .0050       | .0020     | 8.9310           | 4.5630    | 13.27                                         | 3.94         | 22.63                              | 9  |
| 36.60                         | 21.40      | 15.20      | 1.3720      | 0.7160 | .2800      | .4360      | 7.50      | .0070       | .0350     | 7.4100           | 5.7090    | 10.05                                         | 3.02         | 18.21                              | 10 |
| 36.80                         | 18.40      | 18.40      | 1.1140      | 0.3820 | .1980      | .1840      | 7.30      | .0100       | .0150     | 6.4350           | 4.3680    | 12.86                                         | 3.26         | 25.56                              | 11 |
| 20.20                         | 18.20      | 2.00       | 0.4940      | 0.1160 | .0580      | .0580      | 2.20      | .0300       | .0150     | 2.8860           | 2.4960    | 12.32                                         | 1.66         | 20.42                              | 12 |
| 45.00                         | 23.20      | 21.80      | 1.9580      | 0.7620 | .2260      | .5360      | 6.90      | .0050       | .0048     | 8.9700           | 5.1480    | 15.83                                         | 3.00         | 26.12                              | 13 |
| 40.20                         | 19.60      | 20.60      | 1.5060      | 1.0960 | .3740      | .7220      | 9.40      | .0020       | .0400     | 9.1260           | 4.4694    | 7.55                                          | 4.52         | 15.61                              | 14 |
| 48.40                         | 45.60      | 2.80       | 1.4380      | 0.6740 | .4360      | .2380      | 7.00      | .0040       | .0120     | 9.1650           | 6.4740    | 27.16                                         | 3.48         | 43.12                              | 15 |
| 12.60                         | 6.00       | 6.60       | 1.0080      | 0.3680 | .0900      | .3080      | 3.80      | .0020       | .0002     | 2.9250           | 1.4430    | 2.64                                          | 3.42         | 7.16                               | 16 |
| 25.80                         | 5.60       | 20.20      | 3.2600      | 0.6100 | .1800      | .4300      | 5.45      | .0080       | .0002     | 4.7970           | 2.7300    | 3.95                                          | 3.46         | 8.53                               | 17 |
| 17.20                         | 8.40       | 8.80       | 2.4560      | 0.7160 | .2560      | .4600      | 8.60      | .0020       | .0004     | 4.0800           | 2.3400    | 2.62                                          | 2.92         | 5.45                               | 18 |
| 24.20                         | 9.20       | 15.00      | 2.2060      | 0.6180 | .1500      | .4680      | 6.45      | .0020       | .0000     | 4.4460           | 2.2230    | 8.73                                          | 3.38         | 13.61                              | 19 |
| 19.60                         | 8.00       | 11.60      | 1.0360      | 0.4900 | .0900      | .3940      | 3.50      | .0250       | .0360     | 3.5880           | 1.0530    | 3.30                                          | 3.58         | 7.14                               | 20 |
| 40.80                         | 18.80      | 22.00      | 2.7240      | 1.1060 | .6660      | .4400      | 6.85      | .0000       | .0004     | 11.3100          | 4.0560    | 9.67                                          | 3.90         | 15.54                              | 21 |
| 59.00                         | 24.00      | 35.00      | 1.6240      | 1.0660 | .4420      | .6240      | 8.45      | .0100       | .0160     | 9.5940           | 6.7808    | 9.31                                          | 3.12         | 14.73                              | 22 |
| 54.60                         | 19.20      | 35.40      | 0.9040      | 1.1640 | .2520      | .9120      | 4.00      | .0000       | .0250     | 12.7140          | 3.8220    | 16.03                                         | 2.94         | 19.33                              | 23 |
| 22.00                         | 4.20       | 17.80      | 0.2440      | 0.3820 | .0800      | .3020      | 2.25      | .0200       | .0277     | 7.4100           | 2.1450    | 4.22                                          | 2.60         | 4.70                               | 24 |
| 50.40                         | 41.60      | 8.80       | 1.5740      | 0.5500 | .2100      | .8260      | 7.60      | .0080       | .0125     | 10.7640          | 6.8250    | 21.61                                         | 3.22         | 29.84                              | 25 |
| 40.80                         | 26.80      | 14.00      | 1.1440      | 0.8900 | .6580      | .3320      | 9.80      | .0020       | .0300     | 8.5800           | 6.7860    | 9.47                                          | 2.86         | 18.43                              | 26 |
| 124.80                        | 24.80      | 100.00     | 1.1160      | 1.1460 | .1920      | .9540      | 9.10      | .0080       | .0160     | 13.3580          | 4.1340    | 15.10                                         | 2.86         | 21.17                              | 27 |
| 17.20                         | 5.60       | 11.60      | 0.4680      | 0.2400 | .0480      | .1920      | 2.90      | .0500       | .0260     | 4.4380           | 1.3880    | 2.22                                          | 2.64         | 5.08                               | 28 |
| 37.33                         | 19.11      | 18.22      | 1.3694      | 0.6397 | .2452      | .3945      | 6.34      | .0155       | .0155     | 7.7654           | 4.0071    | 10.08                                         | 3.11         | 17.47                              | 29 |

## Samples by Days.

|       |       |       |        |       |       |       |      |       |       |         |        |       |      |       |    |
|-------|-------|-------|--------|-------|-------|-------|------|-------|-------|---------|--------|-------|------|-------|----|
| 32.30 | 19.15 | 13.15 | 1.1200 | .5410 | .2240 | .3170 | 5.91 | .0295 | .0092 | 8.5643  | 3.8154 | 9.03  | 2.92 | 17.58 | 30 |
| 33.75 | 20.25 | 13.50 | 1.0925 | .6205 | .2485 | .2720 | 6.48 | .0290 | .0210 | 7.9170  | 4.5143 | 9.58  | 2.94 | 19.13 | 31 |
| 34.60 | 21.75 | 12.85 | 1.2330 | .4505 | .1875 | .2640 | 6.49 | .0130 | .0168 | 6.4155  | 4.2840 | 12.13 | 2.95 | 21.71 | 32 |
| 36.55 | 23.60 | 12.95 | 1.4770 | .7250 | .2740 | .4510 | 6.78 | .0033 | .0143 | 7.5465  | 4.3836 | 13.30 | 3.61 | 23.01 | 33 |
| 21.70 | 7.80  | 13.90 | 2.2795 | .6085 | .1705 | .4390 | 6.00 | .0093 | .0091 | 4.3778  | 2.0865 | 4.65  | 3.34 | 8.08  | 34 |
| 44.10 | 16.55 | 27.55 | 1.3490 | .9235 | .3600 | .6695 | 6.39 | .0075 | .0173 | 10.2570 | 4.1828 | 9.81  | 3.14 | 13.58 | 35 |
| 58.30 | 24.70 | 33.60 | 1.0750 | .7030 | .2520 | .4610 | 7.35 | .0170 | .0211 | 9.2900  | 4.7833 | 12.10 | 2.90 | 18.63 | 36 |
| 37.33 | 19.11 | 18.21 | 1.3694 | .6397 | .2452 | .3945 | 6.34 | .0155 | .0155 | 7.7654  | 4.0071 | 10.08 | 3.11 | 17.47 | 37 |

## Corresponding Hours during the Week.

|       |       |       |        |       |       |       |      |       |       |        |        |       |      |       |    |
|-------|-------|-------|--------|-------|-------|-------|------|-------|-------|--------|--------|-------|------|-------|----|
| 41.40 | 23.03 | 18.46 | 2.1537 | .7057 | .2794 | .4263 | 7.30 | .0044 | .0057 | 9.6523 | 4.9399 | 12.29 | 3.37 | 20.64 | 38 |
| 38.37 | 20.43 | 17.94 | 1.4491 | .8237 | .3400 | .4837 | 8.33 | .0069 | .0214 | 8.9791 | 5.1176 | 7.03  | 3.22 | 15.23 | 39 |
| 53.26 | 25.66 | 27.60 | 1.2774 | .7611 | .2963 | .4648 | 6.87 | .0054 | .0135 | 8.8279 | 4.4040 | 16.65 | 3.10 | 25.70 | 40 |
| 16.20 | 7.34  | 8.86  | 0.5974 | .2683 | .0651 | .2031 | 2.86 | .0453 | .0215 | 8.6025 | 1.5669 | 4.36  | 2.75 | 8.43  | 41 |
| 37.33 | 19.11 | 18.21 | 1.3694 | .6397 | .2452 | .3945 | 6.34 | .0155 | .0155 | 7.7654 | 4.0071 | 10.08 | 3.11 | 17.47 | 42 |

to the precipitation works, just in front of the screen through which the sewage passes before being portions, collected at half hour intervals. The first collection was made at 8 A. M., Sept. 4, 1895.

## BLACKSTONE RIVER.

## Chemical Examination of Effluent from

[Parts per 100,000.]

| Number. | DATE OF—                      |                    | APPEARANCE.      |                    |        | RESIDUE ON EVAPORATION. |            |            |
|---------|-------------------------------|--------------------|------------------|--------------------|--------|-------------------------|------------|------------|
|         | Collection—1895.              | Examination, 1895. | Turbidity.       | Sediment.          | Color. | TOTAL RESIDUE.          |            |            |
|         |                               |                    |                  |                    |        | Total.                  | Dissolved. | Suspended. |
|         | September.                    | Sept.              |                  |                    |        |                         |            |            |
| 1       | 14982 4, 2 P.M. to 8 P.M.     | 5                  | Decided.         | Slight, yellow.    | .35    | 62.40                   | 59.20      | 3.20       |
| 2       | 14991 4-5, 8 P.M. to 2 A.M.   | 5                  | Decided, milky.  | Slight, yellow.    | .25    | 61.60                   | 60.10      | 1.50       |
| 3       | 14996 5, 2 A.M. to 8 A.M.     | 5                  | Distinct, milky. | Slight, light.     | .30    | 63.40                   | 62.20      | 1.20       |
| 4       | 15007 5, 8 A.M. to 2 P.M.     | 6                  | Decided.         | Slight, rusty.     | .30    | 46.60                   | 45.40      | 1.20       |
| 5       | 15011 5, 2 P.M. to 8 P.M.     | 6                  | Decided, milky.  | Slight, rusty.     | .30    | 61.40                   | 60.00      | 1.40       |
| 6       | 15016 5-6, 8 P.M. to 2 A.M.   | 6                  | Decided, milky.  | Slight, yellow.    | .30    | 67.20                   | 62.20      | 5.00       |
| 7       | 15018 6, 2 A.M. to 8 A.M.     | 6                  | Decided, milky.  | Slight, yellow.    | .30    | 56.60                   | 56.20      | 0.40       |
| 8       | 15024 6, 8 A.M. to 2 P.M.     | 7                  | Distinct, milky. | Slight, yellow.    | .20    | 43.80                   | 43.40      | 0.40       |
| 9       | 15031 6, 2 P.M. to 8 P.M.     | 7                  | Decided, milky.  | Slight, rusty.     | .30    | 63.20                   | 60.20      | 3.00       |
| 10      | 15035 6-7, 8 P.M. to 2 A.M.   | 7                  | Decided, milky.  | V. slight, yellow. | .25    | 63.80                   | 62.80      | 1.00       |
| 11      | 15037 7, 2 A.M. to 8 A.M.     | 7                  | Decided, milky.  | Slight, yellow.    | .20    | 64.40                   | 64.00      | 0.40       |
| 12      | 15055 7, 8 A.M. to 2 P.M.     | 8                  | Slight, rusty.   | Slight, rusty.     | .70    | 55.80                   | 52.60      | 3.20       |
| 13      | 15056 7, 2 P.M. to 8 P.M.     | 8                  | Distinct, rusty. | Slight, rusty.     | .15    | 68.60                   | 63.80      | 4.80       |
| 14      | 15064 7-8, 8 P.M. to 2 A.M.   | 8                  | Decided, milky.  | Slight, yellow.    | .20    | 67.60                   | 67.00      | 0.60       |
| 15      | 15065 8, 2 A.M. to 8 A.M.     | 8                  | Decided, milky.  | Slight, yellow.    | .25    | 69.80                   | 65.80      | 4.00       |
| 16      | 15066 8, 8 A.M. to 2 P.M.     | 8                  | Decided, milky.  | Slight, yellow.    | .25    | 49.20                   | 46.00      | 3.20       |
| 17      | 15075 8, 2 P.M. to 8 P.M.     | 9                  | Decided, milky.  | Slight, brown.     | .40    | 50.60                   | 43.40      | 7.20       |
| 18      | 15080 8-9, 8 P.M. to 2 A.M.   | 9                  | Decided, milky.  | Slight, rusty.     | .35    | 49.20                   | 43.80      | 5.40       |
| 19      | 15091 9, 2 A.M. to 8 A.M.     | 9                  | Distinct, milky. | Slight, rusty.     | .30    | 43.60                   | 39.40      | 4.20       |
| 20      | 15101 9, 8 A.M. to 2 P.M.     | 10                 | Decided, milky.  | Slight, yellow.    | .30    | 40.00                   | 39.00      | 1.00       |
| 21      | 15115 9, 2 P.M. to 8 P.M.     | 10                 | Decided, milky.  | Slight, dark.      | .65    | 54.80                   | 53.80      | 1.00       |
| 22      | 15119 9-10, 8 P.M. to 2 A.M.  | 10                 | Decided, milky.  | Cons., dark.       | .40    | 56.20                   | 50.60      | 5.60       |
| 23      | 15121 10, 2 A.M. to 8 A.M.    | 10                 | Decided, milky.  | Cons., brown.      | .50    | 52.00                   | 45.60      | 6.40       |
| 24      | 15141 10, 8 A.M. to 2 P.M.    | 11                 | Slight, rusty.   | Cons., rusty.      | .20    | 38.60                   | 36.00      | 2.60       |
| 25      | 15143 10, 2 P.M. to 8 P.M.    | 11                 | Decided, milky.  | Slight, rusty.     | .40    | 58.40                   | 58.00      | 0.40       |
| 26      | 15151 10-11, 8 P.M. to 2 A.M. | 11                 | Decided, milky.  | Slight, brown.     | .40    | 72.00                   | 71.80      | 0.20       |
| 27      | 15153 11, 2 A.M. to 8 A.M.    | 11                 | Distinct, milky. | Slight, brown.     | .39    | 63.00                   | 63.20      | 1.80       |
| 28      | 15156 11, 8 A.M. to 2 P.M.    | 12                 | Decided, milky.  | Slight, yellow.    | .25    | 46.00                   | 44.00      | 2.00       |
| 29      | Av.                           | .....              | .....            | .....              | .32    | 56.85                   | 54.27      | 2.58       |

## Averages of the Above

|    |                                                                     |     |       |       |      |
|----|---------------------------------------------------------------------|-----|-------|-------|------|
| 30 | For the 24 hours beginning at 2 P.M., Wednesday, September 4, . . . | .70 | 58.50 | 56.73 | 1.77 |
| 31 | For the 24 hours beginning at 2 P.M., Thursday, September 5, . . .  | .27 | 57.25 | 55.45 | 1.80 |
| 32 | For the 24 hours beginning at 2 P.M., Friday, September 6, . . .    | .37 | 61.80 | 59.90 | 1.90 |
| 33 | For the 24 hours beginning at 2 P.M., Saturday, September 7, . . .  | .21 | 63.80 | 60.65 | 3.15 |
| 34 | For the 24 hours beginning at 2 P.M., Sunday, September 8, . . .    | .34 | 45.85 | 41.40 | 4.45 |
| 35 | For the 24 hours beginning at 2 P.M., Monday, September 9, . . .    | .44 | 50.40 | 46.50 | 3.90 |
| 36 | For the 24 hours beginning at 2 P.M., Tuesday, September 10, . . .  | .34 | 60.35 | 59.25 | 1.10 |
| 37 | Average, . . . . .                                                  | .32 | 56.85 | 54.27 | 2.58 |

## Averages of Samples collected

|    |                                                |     |       |       |      |
|----|------------------------------------------------|-----|-------|-------|------|
| 38 | For the hours from 2 P.M. to 8 P.M., . . . . . | .36 | 59.91 | 56.91 | 3.00 |
| 39 | For the hours from 8 P.M. to 2 A.M., . . . . . | .31 | 62.51 | 59.76 | 2.76 |
| 40 | For the hours from 2 A.M. to 8 A.M., . . . . . | .31 | 59.26 | 56.63 | 2.63 |
| 41 | For the hours from 8 A.M. to 2 P.M., . . . . . | .31 | 45.71 | 43.77 | 1.94 |
| 42 | Average, . . . . .                             | .32 | 56.85 | 54.27 | 2.58 |

Odor, offensive. The samples were collected from the channel which conveys the effluent from up of twelve equal portions collected at half-hour intervals. The first collection was made at 2 P.M.,

## BLACKSTONE RIVER.

*the Worcester Sewage Precipitation Works.*

Parts per 100,000.]

| RESIDUE ON EVAPORATION—CON. |            |            | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | OXYGEN CONSUMED. |           | Iron Oxide (Fe <sub>2</sub> O <sub>3</sub> ). | Lime (Ca O). | Sulphuric Acid (SO <sub>3</sub> ). |    |
|-----------------------------|------------|------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|-----------------------------------------------|--------------|------------------------------------|----|
| LOSS ON IGNITION.           |            |            | Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. | Unfiltered.      | Filtered. |                                               |              |                                    |    |
| Total.                      | Dissolved. | Suspended. |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |                                               |              |                                    |    |
| 12.80                       | 12.20      | 0.60       | 1.2340   | .2180       | .1860      | .0320      | 6.80      | .0200       | .0240     | 2.3716           | 2.2946    | 0.02                                          | 18.30        | 19.06                              | 1  |
| 13.60                       | 13.00      | 0.60       | 1.1960   | .2900       | .2440      | .0460      | 6.60      | .0300       | .0105     | 2.6565           | 2.2946    | 0.00                                          | 15.40        | 17.36                              | 2  |
| 16.60                       | 14.80      | 0.80       | 1.1160   | .5720       | .3860      | .1860      | 6.80      | .0400       | .0090     | 3.0030           | 2.7720    | 0.10                                          | 22.24        | 16.82                              | 3  |
| 9.80                        | 8.60       | 1.20       | 0.8760   | .2240       | .1700      | .0540      | 4.70      | .0450       | .0350     | 2.5740           | 2.1060    | 0.02                                          | 12.40        | 13.77                              | 4  |
| 12.40                       | 12.00      | 0.40       | 1.1880   | .2160       | .1820      | .0340      | 6.55      | .0450       | .0444     | 2.7300           | 2.7300    | 0.02                                          | 15.08        | 19.06                              | 5  |
| 13.60                       | 11.20      | 2.40       | 1.4480   | .2640       | .2060      | .0580      | 7.00      | .0080       | .0620     | 2.8860           | 2.8080    | 0.02                                          | 17.13        | 18.62                              | 6  |
| 13.00                       | 12.60      | 0.40       | 1.1420   | .2340       | .1920      | .0420      | 6.40      | .0200       | .0600     | 2.7300           | 2.2620    | 0.06                                          | 15.14        | 17.02                              | 7  |
| 8.80                        | 8.00       | 0.80       | 1.0020   | .1420       | .1260      | .0160      | 4.60      | .0500       | .0400     | 2.1840           | 1.4430    | 1.71                                          | 12.42        | 14.35                              | 8  |
| 13.40                       | 11.60      | 1.80       | 0.7020   | .2060       | .1620      | .0440      | 6.70      | .0300       | .0500     | 3.1200           | 2.6910    | 0.02                                          | 16.10        | 19.73                              | 9  |
| 10.60                       | 10.40      | 0.20       | 1.3940   | .2040       | .1820      | .0220      | 6.90      | .0040       | .0600     | 3.1200           | 2.8080    | 0.10                                          | 17.24        | 20.55                              | 10 |
| 13.40                       | 13.00      | 0.40       | 0.9560   | .2020       | .1920      | .0100      | 6.90      | .0050       | .0670     | 2.5740           | 2.4336    | 0.19                                          | 17.20        | 20.50                              | 11 |
| 8.40                        | 7.80       | 0.60       | 0.9580   | .1320       | .1040      | .0280      | 4.75      | .0200       | .0480     | 1.8330           | 1.7316    | 0.02                                          | 15.35        | 19.04                              | 12 |
| 15.00                       | 10.60      | 4.40       | 1.8780   | .1980       | .1600      | .0380      | 6.40      | .0180       | .0200     | 2.6130           | 2.4336    | 0.16                                          | 18.72        | 23.67                              | 13 |
| 13.20                       | 12.60      | 0.60       | 1.3100   | .2240       | .1940      | .0300      | 7.20      | .0000       | .0380     | 2.3790           | 2.3400    | 0.02                                          | 16.36        | 21.04                              | 14 |
| 14.60                       | 13.60      | 1.00       | 1.3100   | .3460       | .2700      | .0760      | 7.30      | .0140       | .0440     | 2.4960           | 2.4180    | 0.06                                          | 15.84        | 20.51                              | 15 |
| 11.20                       | 10.20      | 1.00       | 1.4900   | .1940       | .1780      | .0160      | 5.05      | .0480       | .0520     | 1.6770           | 1.5210    | 0.07                                          | 10.96        | 14.41                              | 16 |
| 8.00                        | 6.00       | 3.00       | 2.7760   | .3500       | .2520      | .0980      | 6.70      | .0200       | .0460     | 1.8720           | 1.7940    | 0.21                                          | 10.64        | 13.00                              | 17 |
| 6.80                        | 6.40       | 0.40       | 2.0560   | .2560       | .1720      | .0840      | 7.30      | .0000       | .0004     | 1.9890           | 1.9500    | 0.16                                          | 9.88         | 12.46                              | 18 |
| 5.20                        | 5.00       | 0.20       | 2.0560   | .2040       | .1780      | .0280      | 6.40      | .0150       | .0520     | 1.7940           | 1.7160    | 0.22                                          | 9.66         | 12.40                              | 19 |
| 7.00                        | 6.60       | 0.40       | 1.6740   | .2180       | .1780      | .0400      | 6.20      | .0000       | .0600     | 1.9890           | 1.9500    | 0.07                                          | 8.02         | 9.37                               | 20 |
| 11.40                       | 11.00      | 0.40       | 2.3240   | .2960       | .2440      | .0820      | 7.40      | .0020       | .0000     | 2.9250           | 2.8470    | 0.04                                          | 11.30        | 13.71                              | 21 |
| 8.80                        | 6.20       | 2.60       | 1.6240   | .2900       | .2420      | .0480      | 7.00      | .0020       | .0001     | 2.7300           | 2.4180    | 0.39                                          | 12.24        | 13.34                              | 22 |
| 8.80                        | 6.00       | 2.80       | 1.0540   | .3320       | .2340      | .0980      | 5.30      | .0020       | .0001     | 2.9481           | 2.0980    | 0.76                                          | 11.20        | 13.30                              | 23 |
| 6.80                        | 6.80       | 0.00       | 0.5240   | .1100       | .0680      | .0120      | 3.60      | .0520       | .0277     | 1.9110           | 1.7160    | 0.21                                          | 9.86         | 11.90                              | 24 |
| 10.40                       | 9.40       | 1.00       | 1.0240   | .1980       | .1600      | .0380      | 5.30      | .0000       | .0300     | 2.4480           | 2.3400    | 0.21                                          | 14.92        | 19.72                              | 25 |
| 15.00                       | 14.20      | 0.80       | 1.4160   | .3760       | .2820      | .0940      | 8.00      | .0000       | .0000     | 3.7830           | 3.1200    | 0.02                                          | 16.38        | 18.88                              | 26 |
| 15.40                       | 14.40      | 1.00       | 1.1660   | .2820       | .2520      | .0300      | 7.80      | .0000       | .0000     | 2.7300           | 2.5350    | 0.02                                          | 14.46        | 16.36                              | 27 |
| 7.60                        | 6.60       | 1.00       | 0.8860   | .1580       | .1440      | .0140      | 5.25      | .0100       | .0180     | 1.7940           | 1.7160    | 0.02                                          | 11.06        | 11.14                              | 28 |
| 11.00                       | 9.90       | 1.10       | 1.3268   | .2477       | .1996      | .0481      | 6.32      | .0179       | .0321     | 2.4950           | 2.2602    | 0.18                                          | 14.12        | 16.54                              | 29 |

*Samples by Days.*

|       |       |      |        |       |       |       |      |       |       |        |        |      |       |       |    |
|-------|-------|------|--------|-------|-------|-------|------|-------|-------|--------|--------|------|-------|-------|----|
| 12.95 | 12.15 | 0.80 | 1.1065 | .3260 | .2465 | .0795 | 6.23 | .0338 | .0199 | 2.6513 | 2.3668 | 0.05 | 17.09 | 16.75 | 30 |
| 1.195 | 10.95 | 1.00 | 1.1950 | .2140 | .1765 | .0375 | 6.14 | .0308 | .0516 | 2.6325 | 2.3107 | 0.45 | 14.94 | 17.41 | 31 |
| 11.45 | 10.70 | 0.75 | 1.0025 | .1860 | .1600 | .0260 | 6.31 | .0145 | .0563 | 2.6618 | 2.4160 | 0.08 | 16.47 | 20.18 | 32 |
| 13.50 | 11.75 | 1.75 | 1.3720 | .2405 | .2005 | .0400 | 6.49 | .0200 | .0385 | 2.2913 | 2.1781 | 0.08 | 15.47 | 19.88 | 33 |
| 6.75  | 5.75  | 1.00 | 2.1405 | .2570 | .1945 | .0625 | 6.65 | .0088 | .0396 | 1.9110 | 1.8525 | 0.17 | 9.55  | 11.93 | 34 |
| 8.95  | 7.50  | 1.45 | 1.3565 | .2570 | .2095 | .0475 | 5.83 | .0145 | .0070 | 2.6285 | 2.2607 | 0.35 | 11.15 | 13.06 | 35 |
| 12.10 | 11.15 | 0.95 | 1.1155 | .2535 | .2095 | .0440 | 6.59 | .0025 | .0120 | 2.6888 | 2.4277 | 0.07 | 14.21 | 16.63 | 36 |
| 11.00 | 9.90  | 1.10 | 1.3268 | .2477 | .1996 | .0481 | 6.32 | .0179 | .0321 | 2.4950 | 2.2602 | 0.18 | 14.12 | 16.53 | 37 |

*at Corresponding Hours.*

|       |       |      |        |       |       |       |      |       |       |        |        |      |       |       |    |
|-------|-------|------|--------|-------|-------|-------|------|-------|-------|--------|--------|------|-------|-------|----|
| 11.91 | 10.26 | 1.66 | 1.5180 | .2403 | .1951 | .0451 | 6.55 | .0193 | .0306 | 2.5824 | 2.4472 | 0.10 | 15.01 | 18.26 | 38 |
| 11.66 | 10.57 | 1.09 | 1.4777 | .2720 | .2174 | .0546 | 7.14 | .0063 | .0246 | 2.7919 | 2.5341 | 0.12 | 14.95 | 17.46 | 39 |
| 12.29 | 11.34 | .94  | 1.2571 | .3103 | .2431 | .0671 | 6.70 | .0137 | .0332 | 2.6107 | 2.3192 | 0.20 | 15.11 | 16.79 | 40 |
| 8.51  | 7.80  | .71  | 1.0543 | .1683 | .1426 | .0257 | 4.88 | .0321 | .0401 | 1.9946 | 1.7405 | 0.30 | 11.44 | 13.63 | 41 |
| 11.00 | 9.90  | 1.10 | 1.3268 | .2477 | .1996 | .0481 | 6.32 | .0179 | .0321 | 2.4950 | 2.2602 | 0.18 | 14.13 | 16.54 | 42 |

the precipitation tank to the Blackstone River. A sample was collected every six hours, and was made Sept. 4, 1895.



**BLACKSTONE RIVER.***Chemical Examination of Water from the Blackstone River at Dam of*

[Parts per 100,000.]

|   | Number. | DATE OF —            |                       | APPEARANCE. |               |        | RESIDUE ON EVAPORATION. |                   |
|---|---------|----------------------|-----------------------|-------------|---------------|--------|-------------------------|-------------------|
|   |         | Collection,<br>1898. | Examination,<br>1898. | Turbidity.  | Sediment.     | Color. | Total.                  | Loss on Ignition. |
| 1 | 14980   | Sept.<br>4           | Sept.<br>5            | Distinct.   | Slight.       | 0.90   | 6.90                    | 3.00              |
| 2 | 15006   | 5                    | 6                     | Distinct.   | Cons., brown. | 0.90   | 8.50                    | 2.70              |
| 3 | 15029   | 6                    | 7                     | Distinct.   | Cons., brown. | 0.95   | 10.10                   | 5.70              |
| 4 | 15052   | 7                    | 8                     | Distinct.   | Cons., brown. | 0.90   | 8.90                    | 4.40              |
| 5 | 15073   | 8                    | 9                     | Distinct.   | Cons., brown. | 1.20   | -                       | -                 |
| 6 | 15112   | 9                    | 10                    | Decided.    | Cons., rusty. | 0.90   | 8.70                    | 2.80              |
| 7 | 15129   | 10                   | 11                    | Decided.    | Cons., brown. | 0.90   | 8.80                    | 2.50              |
| 8 | Av...   | .....                | .....                 | .....       | .....         | 0.95   | 8.65                    | 3.47              |

Odor, vegetable and mouldy, sometimes also disagreeable. — The samples were collected from the hours, beginning at 8 A.M.

## BLACKSTONE RIVER.

*Quinsigamond Iron and Wire Works, just above Mill Brook Channel.*

[Parts per 100,000.]

| AMMONIA. |             |            |             | Chloride. | NITROGEN AS |           | Oxygen Consumed. | Iron (Fe O <sub>2</sub> ). | Lime (Ca O). | Sulphuric Acid (SO <sub>3</sub> ). |   |
|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|----------------------------|--------------|------------------------------------|---|
| Free.    | ALBUMINOID. |            |             |           | Nitrates.   | Nitrites. |                  |                            |              |                                    |   |
|          | Total.      | Dissolved. | Sus-pended. |           |             |           |                  |                            |              |                                    |   |
| .0250    | .0448       | .0384      | .0064       | .60       | .0020       | .0008     | .7099            | -                          | -            | -                                  | 1 |
| .0192    | .0494       | .0398      | .0096       | .56       | .0120       | .0010     | .7063            | -                          | -            | -                                  | 2 |
| .0264    | .0528       | .0414      | .0114       | .96       | .0000       | .0010     | .7605            | -                          | -            | -                                  | 3 |
| .0304    | .0472       | .0416      | .0056       | .60       | .0050       | .0010     | .7644            | -                          | -            | -                                  | 4 |
| .0424    | .0466       | .0398      | .0068       | -         | .0000       | .0012     | .6981            | -                          | -            | -                                  | 5 |
| .0440    | .0438       | .0340      | .0098       | .60       | .0000       | .0005     | .7800            | -                          | -            | -                                  | 6 |
| .0288    | .0490       | .0394      | .0096       | .60       | .0020       | .0012     | .7722            | -                          | -            | -                                  | 7 |
| .0309    | .0477       | .0392      | .0085       | .65       | .0030       | .0010     | .7416            | *.20                       | *.95         | *1.10                              | 8 |

river at the dam. Each sample was made up of four equal portions, collected at intervals of about four

\* These determinations were made upon a mixture of equal parts of water from all the samples.

**BLACKSTONE RIVER.***Chemical Examination of Water from the Blackstone River between the*

[Parts per 100,000.]

| Number. | DATE OF—                      |                    | APPEARANCE.       |                |        | RESIDUE ON EVAPORATION. |            |            |
|---------|-------------------------------|--------------------|-------------------|----------------|--------|-------------------------|------------|------------|
|         | Collection—1893.              | Examination, 1893. | Turbidity.        | Sediment.      | Color. | TOTAL RESIDUE.          |            |            |
|         |                               |                    |                   |                |        | Total.                  | Dissolved. | Suspended. |
|         | September.                    | Sept.              |                   |                |        |                         |            |            |
| 1       | 14973 4, 8 A.M. to 2 P.M.     | 5                  | Decided, rusty.   | Heavy, rusty.  | 0.03   | 16.80                   | 13.60      | 3.20       |
| 2       | 14983 4, 2 P.M. to 8 P.M.     | 5                  | Distinct.         | Heavy, rusty.  | 0.04   | 21.60                   | 18.80      | 2.80       |
| 3       | 14994 4-6, 8 P.M. to 8 A.M.   | 5                  | Distinct.         | Cons., rusty.  | 0.05   | 16.20                   | 15.20      | 1.00       |
| 4       | 15008 5, 8 A.M. to 2 P.M.     | 6                  | Distinct.         | Heavy, rusty.  | 0.08   | 17.00                   | 13.60      | 3.40       |
| 5       | 15012 5, 2 P.M. to 8 P.M.     | 6                  | Slight.           | Heavy, rusty.  | 0.10   | 22.40                   | 19.40      | 3.00       |
| 6       | 15019 5-6, 8 P.M. to 8 A.M.   | 6                  | Decided, milky.   | Slight, rusty. | 0.04   | 14.40                   | 13.00      | 1.40       |
| 7       | 15025 6, 8 A.M. to 2 P.M.     | 7                  | Dist't, yellow.   | Cons., rusty.  | 0.30   | 19.80                   | 18.60      | 1.20       |
| 8       | 15032 6, 2 P.M. to 8 P.M.     | 7                  | Slight, yellow.   | Cons., rusty.  | 0.05   | 35.00                   | 34.40      | 0.60       |
| 9       | 15038 6-7, 8 P.M. to 8 A.M.   | 7                  | Decided, milky.   | Slight, rusty. | 0.10   | 28.00                   | 27.60      | 0.40       |
| 10      | 15057 7, 8 A.M. to 2 P.M.     | 8                  | V. slight, rusty. | Heavy, rusty.  | 0.10   | 26.60                   | 23.00      | 3.60       |
| 11      | 15058 7, 2 P.M. to 8 P.M.     | 8                  | Slight, rusty.    | Heavy, rusty.  | 0.10   | 17.80                   | 14.20      | 3.60       |
| 12      | 15067 7-8, 8 P.M. to 8 A.M.   | 8                  | Distinct, milky.  | Cons., brown.  | 0.50   | 51.20                   | 47.00      | 4.20       |
| 13      | 15068 8, 8 A.M. to 2 P.M.     | 8                  | Decided, rusty.   | Heavy, rusty.  | 0.25   | 21.20                   | 18.40      | 2.80       |
| 14      | 15076 8, 2 P.M. to 8 P.M.     | 9                  | Decided, rusty.   | Heavy, rusty.  | 0.70   | 22.20                   | 20.80      | 1.40       |
| 15      | 15092 8-9, 8 P.M. to 8 A.M.   | 9                  | Distinct, milky.  | Heavy, rusty.  | 0.30   | 24.20                   | 18.80      | 5.40       |
| 16      | 15102 9, 8 A.M. to 2 P.M.     | 10                 | Slight, milky.    | Heavy, rusty.  | 0.10   | 24.00                   | 17.20      | 6.80       |
| 17      | 15116 9, 2 P.M. to 8 P.M.     | 10                 | Slight, milky.    | Heavy, rusty.  | 0.10   | 16.80                   | 11.00      | 5.80       |
| 18      | 15122 9-10, 8 P.M. to 8 A.M.  | 10                 | Thick, brown.     | Cons., dark.   | 1.00   | 46.00                   | 14.60      | 31.40      |
| 19      | 15144 10, 8 A.M. to 2 P.M.    | 11                 | Distinct, rusty.  | Heavy, rusty.  | 0.15   | 20.80                   | 16.00      | 4.80       |
| 20      | 15146 10, 2 P.M. to 8 P.M.    | 11                 | Decided, milky.   | Heavy, rusty.  | 0.15   | 15.80                   | 12.20      | 3.60       |
| 21      | 15154 10-11, 8 P.M. to 8 A.M. | 11                 | Decided, milky.   | Slight, rusty. | 0.02   | 14.80                   | 14.00      | 0.80       |
| 22      | Av. ....                      |                    |                   |                | 0.20   | 23.46                   | 19.11      | 4.35       |

*Averages of the Above*

|    |                                                                     |      |       |       |       |
|----|---------------------------------------------------------------------|------|-------|-------|-------|
| 23 | For the 24 hours beginning at 8 A.M., Wednesday, September 4, . . . | 0.04 | 18.20 | 15.87 | 2.33  |
| 24 | For the 24 hours beginning at 8 A.M., Thursday, September 5, . . .  | 0.07 | 17.93 | 15.33 | 2.60  |
| 25 | For the 24 hours beginning at 8 A.M., Friday, September 6, . . .    | 0.15 | 27.60 | 26.87 | 0.73  |
| 26 | For the 24 hours beginning at 8 A.M., Saturday, September 7, . . .  | 0.23 | 31.87 | 28.07 | 3.80  |
| 27 | For the 24 hours beginning at 8 A.M., Sunday, September 8, . . .    | 0.42 | 22.53 | 19.33 | 3.20  |
| 28 | For the 24 hours beginning at 8 A.M., Monday, September 9, . . .    | 0.40 | 28.93 | 14.27 | 14.67 |
| 29 | For the 24 hours beginning at 8 A.M., Tuesday, September 10, . . .  | 0.11 | 17.18 | 14.07 | 3.07  |
| 30 | Average, . . . . .                                                  | 0.20 | 23.46 | 19.12 | 4.34  |

*Averages of Samples collected*

|    |                                                |      |       |       |      |
|----|------------------------------------------------|------|-------|-------|------|
| 31 | For the hours from 8 A.M. to 2 P.M., . . . . . | 0.14 | 20.59 | 17.20 | 3.69 |
| 32 | For the hours from 2 P.M. to 8 P.M., . . . . . | 0.18 | 21.66 | 18.69 | 2.97 |
| 33 | For the hours from 8 P.M. to 8 A.M., . . . . . | 0.29 | 27.83 | 21.46 | 6.37 |
| 34 | Average, . . . . .                             | 0.20 | 23.46 | 19.12 | 4.34 |

Odor, tarry, often disagreeable. — The samples were collected from the river, at a temporary bridge from these works enters the river.

Three samples were collected each twenty-four hours. The first was made up of three equal portions, collected at intervals of two hours, beginning at 3 P.M.; the third sample was made up of two

## BLACKSTONE RIVER.

*Mill Brook Channel and the Worcester Sewage Precipitation Works.*

[Parts per 100,000.]

| RESIDUE ON EVAPORATION - COH. |            |            | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | OXYGEN CONSUMED. |           | Iron Oxide (Feg Og). | Lime (Ca O). | Sulphuric Acid (SO <sub>3</sub> ) |    |
|-------------------------------|------------|------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|----------------------|--------------|-----------------------------------|----|
| LOSS ON IGNITION.             |            |            | Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. | Unfiltered.      | Filtered. |                      |              |                                   |    |
| Total.                        | Dissolved. | Suspended. |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |                      |              |                                   |    |
| 2.20                          | 2.00       | 0.20       | 0.2748   | .0520       | .0340      | .0180      | 0.08      | .0150       | .0005     | 1.1550           | 0.8855    | 3.15                 | 1.94         | 0.24                              | 1  |
| 6.40                          | 6.40       | 0.00       | 0.1440   | .0320       | .0140      | .0180      | 1.00      | .0030       | .0005     | 1.2936           | 1.1935    | 4.49                 | 1.46         | 7.47                              | 2  |
| 4.20                          | 4.00       | 0.20       | 0.1260   | .0520       | .0400      | .0120      | 0.87      | .0150       | .0003     | 0.9240           | 0.7700    | 2.96                 | 1.64         | 5.27                              | 3  |
| 2.60                          | 2.00       | 0.60       | 0.1960   | .0440       | .0260      | .0180      | 0.88      | .0120       | .0011     | 1.6380           | 1.1700    | 2.89                 | 1.88         | 5.88                              | 4  |
| 5.80                          | 4.80       | 0.80       | 0.1580   | .0460       | .0300      | .0160      | 0.96      | .0060       | .0010     | 1.6380           | 1.5600    | 5.93                 | 1.62         | 8.62                              | 5  |
| 3.80                          | 3.00       | 0.80       | 0.1220   | .0320       | .0160      | .0160      | 0.83      | .0100       | .0009     | 1.3260           | 1.2090    | 2.11                 | 1.44         | 5.91                              | 6  |
| 4.80                          | 3.60       | 1.20       | 0.1820   | .0640       | .0240      | .0400      | 0.96      | .0050       | .0010     | 1.6770           | 1.1856    | 2.59                 | 2.56         | 7.92                              | 7  |
| 12.20                         | 12.20      | 0.00       | 0.1840   | .0960       | .0240      | .0420      | 0.89      | .0000       | .0006     | 2.1060           | 2.1060    | 2.60                 | 1.88         | 13.96                             | 8  |
| 9.80                          | 9.80       | 0.00       | 0.1360   | .0240       | .0200      | .0040      | 0.89      | .0020       | .0009     | 1.6770           | 1.6770    | 6.09                 | 1.90         | 10.67                             | 9  |
| 6.20                          | 6.20       | 0.00       | 0.2280   | .0180       | .0140      | .0040      | 0.90      | .0060       | .0004     | 1.3260           | 1.3260    | 6.27                 | 1.84         | 11.63                             | 10 |
| 2.40                          | 1.40       | 1.00       | 0.1580   | .0260       | .0120      | .0140      | 1.10      | .0040       | .0004     | 1.4040           | 1.1700    | 2.97                 | 1.66         | 7.53                              | 11 |
| 8.60                          | 7.40       | 1.20       | 1.2100   | .2940       | .2000      | .0940      | 5.50      | .0000       | .0000     | 2.2230           | 2.1060    | 0.78                 | 12.54        | 16.29                             | 12 |
| 2.80                          | 1.80       | 1.00       | 0.4700   | .0360       | .0260      | .0100      | 1.22      | .0100       | .0002     | 0.9360           | 0.7410    | 3.73                 | 2.28         | 7.83                              | 13 |
| 7.20                          | 6.80       | 0.40       | 0.5260   | .0460       | .0440      | .0020      | 1.33      | .0050       | .0016     | 1.0140           | 0.6240    | 3.69                 | 2.72         | 7.92                              | 14 |
| 3.00                          | 3.00       | 0.00       | 0.3760   | .0720       | .0480      | .0240      | 1.44      | .0150       | .0015     | 1.1700           | 1.0920    | 3.53                 | 2.50         | 7.92                              | 15 |
| 3.80                          | 1.60       | 2.20       | 0.1510   | .0420       | .0220      | .0200      | 1.47      | .0030       | .0004     | 1.4040           | 1.2320    | 4.36                 | 2.02         | 10.98                             | 16 |
| 3.20                          | 1.80       | 1.40       | 0.2140   | .0460       | .0320      | .0140      | 1.05      | .0080       | .0010     | 1.5990           | 1.1700    | 1.97                 | 1.86         | 4.71                              | 17 |
| 8.60                          | 4.40       | 4.20       | 0.2640   | .1820       | .0780      | .1040      | 1.70      | .0450       | .0166     | 3.7050           | 1.5990    | 3.53                 | 1.92         | 4.01                              | 18 |
| 6.00                          | 2.00       | 3.60       | 0.1640   | .0520       | .0220      | .0300      | 1.18      | .0300       | .0020     | 1.2480           | 0.6864    | 3.23                 | 1.80         | 6.35                              | 19 |
| 3.20                          | 1.80       | 1.40       | 0.1140   | .0520       | .0320      | .0200      | 1.16      | .0020       | .0005     | 1.3260           | 1.1540    | 1.74                 | 1.76         | 4.39                              | 20 |
| 1.80                          | 0.80       | 1.00       | 0.1160   | .0460       | .0340      | .0120      | 1.01      | .0200       | .0001     | 1.0920           | 0.7410    | 1.34                 | 1.52         | 4.60                              | 21 |
| 5.17                          | 4.16       | 1.01       | 0.2627   | .0678       | .0377      | .0301      | 1.23      | .0102       | .0015     | 1.5182           | 1.2094    | 3.33                 | 2.41         | 7.91                              | 22 |

*Samples by Days.*

|      |      |      |       |       |       |       |      |       |       |        |        |      |      |       |    |
|------|------|------|-------|-------|-------|-------|------|-------|-------|--------|--------|------|------|-------|----|
| 4.27 | 4.13 | 0.13 | .1813 | .0453 | .0293 | .0160 | 0.62 | .0110 | .0004 | 1.1242 | 0.9497 | 3.53 | 1.65 | 6.33  | 23 |
| 4.00 | 3.27 | 0.73 | .1587 | .0740 | .0240 | .0500 | 0.89 | .0090 | .0010 | 1.5340 | 1.3130 | 3.64 | 1.65 | 6.80  | 24 |
| 8.93 | 8.53 | 0.40 | .1673 | .0513 | .0227 | .0287 | 0.72 | .0023 | .0008 | 1.8200 | 1.6562 | 3.76 | 2.11 | 10.85 | 25 |
| 5.73 | 5.00 | 0.73 | .5320 | .1127 | .0753 | .0373 | 2.50 | .0033 | .0003 | 1.6510 | 1.5840 | 3.84 | 5.55 | 11.82 | 26 |
| 4.53 | 4.07 | 0.47 | .4573 | .0513 | .0393 | .0120 | 1.33 | .0100 | .0011 | 1.0400 | 0.8190 | 3.65 | 2.50 | 7.89  | 27 |
| 5.20 | 2.60 | 2.60 | .2107 | .0900 | .0440 | .0460 | 1.41 | .0187 | .0060 | 2.2360 | 1.3337 | 3.29 | 1.93 | 6.57  | 28 |
| 3.53 | 1.53 | 2.00 | .1313 | .0500 | .0293 | .0207 | 1.12 | .0173 | .0009 | 1.2220 | 0.8605 | 2.10 | 1.69 | 5.11  | 29 |
| 5.17 | 4.16 | 1.01 | .2627 | .0678 | .0377 | .0301 | 1.23 | .0102 | .0015 | 1.5182 | 1.2094 | 3.33 | 2.41 | 7.91  | 30 |

*at Corresponding Hours.*

|      |      |      |       |       |       |       |      |       |       |        |        |      |      |      |    |
|------|------|------|-------|-------|-------|-------|------|-------|-------|--------|--------|------|------|------|----|
| 4.00 | 2.74 | 1.26 | .2383 | .0440 | .0240 | .0200 | 1.03 | .0116 | .0008 | 1.8406 | 1.0324 | 3.75 | 2.05 | 8.12 | 31 |
| 5.74 | 5.03 | 0.71 | .2140 | .0449 | .0269 | .0180 | 0.93 | .0033 | .0008 | 1.4829 | 1.2825 | 3.34 | 1.85 | 7.80 | 32 |
| 5.77 | 4.71 | 1.06 | .3357 | .1146 | .0623 | .0523 | 1.72 | .0163 | .0029 | 1.7310 | 1.3134 | 2.91 | 3.34 | 7.81 | 33 |
| 5.17 | 4.16 | 1.01 | .2627 | .0678 | .0377 | .0301 | 1.23 | .0102 | .0015 | 1.5182 | 1.2094 | 3.33 | 2.41 | 7.91 | 34 |

built opposite the sludge beds of the Worcester precipitation works, and above the place where the effluent portions, collected at intervals of about two hours, beginning at 9 A.M.; the second, also of three equal portions, collected at 1 A.M. and 7 A.M.

## BLACKSTONE RIVER.

## Chemical Examination of Water from the Blackstone

[Parts per 100,000.]

| Number. | DATE OF —                     |                    | APPEARANCE.      |                |        | RESIDUE ON EVAPORATION. |            |            |
|---------|-------------------------------|--------------------|------------------|----------------|--------|-------------------------|------------|------------|
|         | Collection — 1895.            | Examination, 1895. | Turbidity.       | Sediment.      | Color. | TOTAL RESIDUE.          |            |            |
|         |                               |                    |                  |                |        | Total.                  | Dissolved. | Suspended. |
|         | September.                    | Sept.              |                  |                |        |                         |            |            |
| 1       | 14974 4, 8 A.M. to 2 P.M.     | 5                  | Distinct, rusty. | Heavy, rusty.  | .10    | 35.60                   | 31.20      | 4.40       |
| 2       | 14984 4, 2 P.M. to 8 P.M.     | 5                  | Decided, rusty.  | Heavy, rusty.  | .10    | 37.40                   | 34.20      | 3.20       |
| 3       | 14985 4-5, 8 P.M. to 8 A.M.   | 5                  | Decided, milky.  | Cons., rusty.  | .20    | 38.40                   | 36.00      | 2.40       |
| 4       | 15006 5, 8 A.M. to 2 P.M.     | 6                  | Decided, milky.  | Heavy, rusty.  | .15    | 35.80                   | 32.00      | 3.80       |
| 5       | 15013 5, 2 P.M. to 8 P.M.     | 6                  | Distinct.        | Heavy, rusty.  | .50    | 42.80                   | 37.40      | 5.40       |
| 6       | 15020 5-6, 8 P.M. to 8 A.M.   | 6                  | V. dec'd, milky. | Slight, rusty. | .20    | 39.60                   | 38.00      | 1.60       |
| 7       | 15026 6, 8 A.M. to 2 P.M.     | 7                  | Distinct, milky. | Cons., rusty.  | .50    | 33.60                   | 32.40      | 1.20       |
| 8       | 15033 6, 2 P.M. to 8 P.M.     | 7                  | Decided, milky.  | Cons., rusty.  | .30    | 48.80                   | 41.40      | 7.40       |
| 9       | 15039 6-7, 8 P.M. to 8 A.M.   | 7                  | Decided, milky.  | Slight, rusty. | .50    | 46.00                   | 42.80      | 3.20       |
| 10      | 15050 7, 8 A.M. to 2 P.M.     | 8                  | Decided, milky.  | Cons., brown.  | .30    | 43.60                   | 40.40      | 3.20       |
| 11      | 15060 7, 2 P.M. to 8 P.M.     | 8                  | Distinct, milky. | Cons., rusty.  | .20    | 46.00                   | 41.00      | 5.00       |
| 12      | 15069 7-8, 8 P.M. to 8 A.M.   | 8                  | Distinct, rusty. | Cons., rusty.  | .40    | 19.20                   | 17.00      | 2.20       |
| 13      | 15070 8, 8 A.M. to 2 P.M.     | 8                  | Decided, milky.  | Cons., rusty.  | .35    | 43.80                   | 42.60      | 1.20       |
| 14      | 15077 8, 2 P.M. to 8 P.M.     | 9                  | Distinct, milky. | Cons., rusty.  | .35    | 45.80                   | 44.40      | 1.40       |
| 15      | 15093 8-9, 8 P.M. to 8 A.M.   | 9                  | Decided, milky.  | Cons., brown.  | .70    | 38.80                   | 34.80      | 4.00       |
| 16      | 15103 9, 8 A.M. to 2 P.M.     | 10                 | Distinct, milky. | Cons., brown.  | .12    | 34.00                   | 28.60      | 5.40       |
| 17      | 15117 9, 2 P.M. to 8 P.M.     | 10                 | Decided, milky.  | Cons., rusty.  | .23    | 36.20                   | 33.40      | 2.80       |
| 18      | 15123 9-10, 8 P.M. to 8 A.M.  | 10                 | Thick, muddy.    | Cons., dark.   | .90    | 51.00                   | 32.00      | 19.00      |
| 19      | 15145 10, 8 A.M. to 2 P.M.    | 11                 | Distinct, milky. | Cons., brown.  | .18    | 32.20                   | 27.80      | 4.40       |
| 20      | 15147 10, 2 P.M. to 8 P.M.    | 11                 | Distinct, milky. | Heavy, rusty.  | .30    | 40.00                   | 38.20      | 1.80       |
| 21      | 15155 10-11, 8 P.M. to 8 A.M. | 11                 | Decided, milky.  | Cons., brown.  | .30    | 39.00                   | 36.00      | 3.00       |
| 22      | Av.                           |                    |                  |                | .33    | 39.41                   | 35.31      | 4.10       |

## Averages of the above

|    |                                                           |     |       |       |      |
|----|-----------------------------------------------------------|-----|-------|-------|------|
| 23 | For the 24 hours beginning at 8 A.M., Wednesday, Sept. 4, | .13 | 37.13 | 33.80 | 3.33 |
| 24 | For the 24 hours beginning at 8 A.M., Thursday, Sept. 5,  | .28 | 39.40 | 35.80 | 3.60 |
| 25 | For the 24 hours beginning at 8 A.M., Friday, Sept. 6,    | .43 | 42.80 | 38.87 | 3.93 |
| 26 | For the 24 hours beginning at 8 A.M., Saturday, Sept. 7,  | .30 | 36.27 | 32.80 | 3.47 |
| 27 | For the 24 hours beginning at 8 A.M., Sunday, Sept. 8,    | .47 | 42.80 | 40.60 | 2.20 |
| 28 | For the 24 hours beginning at 8 A.M., Monday, Sept. 9,    | .42 | 40.40 | 31.33 | 9.07 |
| 29 | For the 24 hours beginning at 8 A.M., Tuesday, Sept. 10,  | .26 | 37.07 | 34.00 | 3.07 |
| 30 | Average, . . . . .                                        | .33 | 39.41 | 35.31 | 4.10 |

## Averages of Samples collected at

|    |                                                |     |       |       |      |
|----|------------------------------------------------|-----|-------|-------|------|
| 31 | For the hours from 8 A.M. to 2 P.M., . . . . . | .24 | 36.94 | 33.57 | 3.37 |
| 32 | For the hours from 2 P.M. to 8 P.M., . . . . . | .28 | 42.43 | 38.57 | 3.86 |
| 33 | For the hours from 8 P.M. to 8 A.M., . . . . . | .46 | 38.86 | 33.80 | 5.06 |
| 34 | Average, . . . . .                             | .33 | 39.41 | 35.31 | 4.10 |

Odor, offensive. — The samples were collected from the river, about one thousand feet below the same manner as those above the precipitation works, but about half an hour later in each case.

## BLACKSTONE RIVER.

*River, below the Worcester Sewage Precipitation Works.*

[Parts per 100,000.]

| RESIDUE ON EVAPORATION—CON. |            |            | AMMONIA.    |        |            |            | Chlorine. | NITROGEN AS |          | OXYGEN CONSUMED. |           | Iron Oxide (Fe <sub>2</sub> O <sub>3</sub> ). | Lime (Ca O). | Sulphuric Acid (SO <sub>3</sub> ). |
|-----------------------------|------------|------------|-------------|--------|------------|------------|-----------|-------------|----------|------------------|-----------|-----------------------------------------------|--------------|------------------------------------|
| LOSS ON IGNITION.           |            |            | ALBUMINOID. |        |            |            |           | Nitrate.    | Nitrite. | Unfiltered.      | Filtered. |                                               |              |                                    |
| Total.                      | Dissolved. | Suspended. | Free.       | Total. | Dissolved. | Suspended. |           |             |          |                  |           |                                               |              |                                    |
| 6.00                        | 5.20       | 0.80       | 0.5240      | .1960  | .1700      | .0280      | 2.95      | .0000       | .0000    | 1.4014           | 1.2705    | 1.52                                          | 8.22         | 11.50                              |
| 9.80                        | 9.80       | 0.00       | 0.5740      | .1640  | .1220      | .0420      | 3.55      | .0150       | .0036    | 1.6555           | 1.3475    | 1.95                                          | 8.14         | 11.85                              |
| 8.00                        | 8.00       | 0.00       | 0.5860      | .1980  | .1640      | .0340      | 3.50      | .0200       | .0048    | 1.5554           | 1.2320    | 1.40                                          | 8.52         | 11.08                              |
| 6.80                        | 5.80       | 1.00       | 0.4680      | .2540  | .2120      | .0420      | 2.75      | .0020       | .0002    | 1.7160           | 1.7160    | 2.04                                          | 8.22         | 11.25                              |
| 8.00                        | 6.80       | 1.20       | 0.5680      | .1360  | .1020      | .0340      | 3.45      | .0300       | .0115    | 2.0280           | 2.0280    | 3.86                                          | 8.28         | 12.76                              |
| 8.20                        | 8.00       | 0.20       | 0.6020      | .1860  | .1500      | .0360      | 4.15      | .0100       | .0200    | 1.8720           | 1.7160    | 1.62                                          | 9.58         | 12.99                              |
| 9.00                        | 9.00       | 0.00       | 0.5720      | .2940  | .1580      | .1260      | 2.70      | .0000       | .0025    | 1.7550           | 1.7316    | 1.76                                          | 7.18         | 11.46                              |
| 9.40                        | 7.40       | 2.00       | 0.7140      | .1800  | .1040      | .0260      | 3.90      | .0200       | .0140    | 1.9500           | 1.6770    | 3.83                                          | 9.36         | 15.37                              |
| 10.60                       | 9.40       | 1.20       | 0.7090      | .1100  | .1080      | .0020      | 4.00      | .0100       | .0380    | 2.1060           | 2.0280    | 2.21                                          | 10.04        | 15.12                              |
| 11.00                       | 9.60       | 1.40       | 0.6280      | .5720  | .4660      | .1060      | 2.90      | .0040       | .0000    | 1.9500           | 1.6770    | 2.89                                          | 8.96         | 15.31                              |
| 8.00                        | 7.20       | 0.80       | 0.7580      | .1600  | .1180      | .0420      | 3.55      | .0150       | .0080    | 2.1060           | 1.8720    | 1.29                                          | 10.42        | 15.89                              |
| 4.60                        | 4.40       | 0.20       | 0.3300      | .0400  | .0220      | .0180      | 1.06      | .0120       | .0002    | 0.8580           | 0.7800    | 2.87                                          | 1.92         | 6.71                               |
| 8.80                        | 8.20       | 0.60       | 1.6100      | .5060  | .4620      | .0440      | 4.50      | .0000       | .0000    | 2.1450           | 1.9890    | 0.50                                          | 10.08        | 15.03                              |
| 9.60                        | 7.80       | 1.80       | 2.2060      | .2000  | .1780      | .0220      | 5.20      | .0020       | .0700    | 1.4430           | 1.3650    | 0.57                                          | 9.54         | 12.10                              |
| 5.20                        | 4.80       | 0.40       | 1.5240      | .1720  | .1540      | .0180      | 4.70      | .0000       | .0320    | 1.7550           | 1.5210    | 1.16                                          | 7.26         | 9.44                               |
| 7.00                        | 4.80       | 2.20       | 0.7540      | .2020  | .1580      | .0440      | 3.20      | .0100       | .0000    | 1.7160           | 1.3104    | 3.72                                          | 5.02         | 9.96                               |
| 7.80                        | 7.80       | 0.00       | 0.7740      | .1580  | .1040      | .0540      | 3.60      | .0080       | .0100    | 2.1450           | 1.9890    | 2.00                                          | 6.66         | 10.37                              |
| 9.60                        | 5.60       | 3.80       | 0.6240      | .2280  | .1340      | .0940      | 3.20      | .0050       | .0001    | 2.5350           | 1.6380    | 2.37                                          | 7.16         | 8.02                               |
| 8.00                        | 6.00       | 2.00       | 0.3440      | .1820  | .1240      | .0580      | 2.80      | .0000       | .0000    | 1.7550           | 1.4430    | 1.73                                          | 6.46         | 10.15                              |
| 8.40                        | 7.80       | 0.60       | 0.5040      | .1740  | .1240      | .0500      | 3.85      | .0180       | .0063    | 2.4570           | 1.7940    | 2.21                                          | 7.08         | 12.34                              |
| 7.80                        | 6.00       | 1.80       | 0.5390      | .2080  | .1640      | .0440      | 4.40      | .0000       | .0000    | 1.7940           | 1.7160    | 1.57                                          | 7.82         | 11.16                              |
| 8.17                        | 7.12       | 1.05       | 0.7574      | .2128  | .1670      | .0458      | 3.52      | .0086       | .0105    | 1.8428           | 1.6115    | 2.05                                          | 7.90         | 11.80                              |

*Samples by Days.*

|      |      |      |        |       |       |       |      |       |       |        |        |      |      |       |    |
|------|------|------|--------|-------|-------|-------|------|-------|-------|--------|--------|------|------|-------|----|
| 7.93 | 7.67 | 0.26 | 0.5613 | .1860 | .1520 | .0340 | 3.33 | .0117 | .0028 | 1.6374 | 1.2833 | 1.62 | 8.29 | 11.48 | 23 |
| 7.67 | 6.87 | 0.80 | 0.5460 | .1920 | .1547 | .0373 | 3.45 | .0140 | .0106 | 1.8720 | 1.8200 | 2.51 | 8.69 | 12.33 | 24 |
| 9.67 | 8.60 | 1.07 | 0.6640 | .1790 | .1267 | .0513 | 3.53 | .0100 | .0183 | 1.9870 | 1.8122 | 2.60 | 8.86 | 13.98 | 25 |
| 7.87 | 7.07 | 0.80 | 0.5720 | .2573 | .2020 | .0563 | 2.50 | .0103 | .0027 | 1.6380 | 1.4430 | 2.35 | 7.10 | 12.64 | 26 |
| 7.87 | 6.93 | 0.94 | 1.7900 | .2927 | .2647 | .0280 | 4.80 | .0007 | .0840 | 1.7810 | 1.6250 | 0.74 | 8.96 | 11.52 | 27 |
| 8.13 | 6.13 | 2.00 | 0.7173 | .1960 | .1320 | .0640 | 3.33 | .0077 | .0034 | 2.1820 | 1.6458 | 2.70 | 6.28 | 9.45  | 28 |
| 8.07 | 6.60 | 1.47 | 0.4613 | .1880 | .1373 | .0507 | 3.68 | .0060 | .0021 | 2.0020 | 1.6510 | 1.84 | 7.12 | 11.21 | 29 |
| 8.17 | 7.12 | 1.05 | 0.7574 | .2128 | .1670 | .0458 | 3.52 | .0086 | .0105 | 1.8428 | 1.6115 | 2.05 | 7.90 | 11.80 | 30 |

*Corresponding Hours during the Week.*

|      |      |      |       |       |       |       |      |       |       |        |        |      |      |       |    |
|------|------|------|-------|-------|-------|-------|------|-------|-------|--------|--------|------|------|-------|----|
| 8.09 | 6.94 | 1.15 | .7000 | .3151 | .2514 | .0637 | 3.11 | .0023 | .0004 | 1.7769 | 1.5911 | 2.02 | 7.73 | 11.81 | 31 |
| 8.71 | 7.80 | 0.91 | .8711 | .1603 | .1217 | .0386 | 3.87 | .0154 | .0176 | 1.9692 | 1.7246 | 2.24 | 8.50 | 12.95 | 32 |
| 7.71 | 6.63 | 1.08 | .7011 | .1631 | .1280 | .0351 | 3.57 | .0081 | .0136 | 1.7822 | 1.5187 | 1.89 | 7.47 | 10.64 | 33 |
| 8.17 | 7.12 | 1.05 | .7574 | .2128 | .1670 | .0458 | 3.52 | .0086 | .0105 | 1.8428 | 1.6115 | 2.05 | 7.90 | 11.80 | 34 |

point where the effluent from the precipitation works enters the stream. The samples were collected in

**BLACKSTONE RIVER.***Chemical Examination of Water from Singletary,*  
[Parts per 100,000.]

| Number. | DATE OF —            |                       | APPEARANCE. |                |                | RESIDUE ON EVAPORATION. |            |                 |                   |            |                 |      |
|---------|----------------------|-----------------------|-------------|----------------|----------------|-------------------------|------------|-----------------|-------------------|------------|-----------------|------|
|         | Collection,<br>1893. | Examination,<br>1893. | Turbidity.  | Sediment.      | Color.         | TOTAL.                  |            |                 | LOSS ON IGNITION. |            |                 |      |
|         |                      |                       |             |                |                | Total.                  | Dissolved. | Sus-<br>pended. | Total.            | Dissolved. | Sus-<br>pended. |      |
|         |                      |                       |             |                |                |                         |            |                 |                   |            |                 |      |
| 1       | 15041                | Sept. 6               | Sept. 7     | Dec'd, milky.  | Slight, dark.  | .40                     | 4.40       | 3.60            | 0.80              | 2.00       | 1.80            | 0.20 |
| 2       | 15098                | 7                     | 9           | Dec'd, purple. | Cons., purple. | .30                     | 9.00       | 8.60            | 0.40              | 3.00       | 2.80            | 0.20 |
| 3       | 15042                | 6                     | 7           | Slight.        | Slight.        | .40                     | 5.80       | 5.70            | 0.10              | 1.80       | 1.70            | 0.10 |
| 4       | 15097                | 7                     | 9           | Slight.        | Slight.        | .40                     | 5.70       | 5.70            | 0.00              | 1.70       | 1.70            | 0.00 |
| 5       | 15043                | 6                     | 7           | Distinct.      | Slight, dark.  | .40                     | 6.20       | -               | -                 | 2.00       | -               | -    |

Odor, of the first sample, disagreeable; of the second, distinct; of the last three, vegetable. — The from Dorothy Brook, above the highway bridge near its mouth; the last one, from Coldspring Brook, at four equal portions, collected at intervals of three hours, as follows: No. 15041 at 7.45 and 10.45 A. M., and A. M., and 2.38 and 5.35 P. M.; No. 15097, at 8.40 and 11.38 A. M., and 2.40 and 5.40 P. M.

*Chemical Examination of Water from the Blackstone*  
[Parts per 100,000.]

|   | Number. | DATE OF —            |                       | APPEARANCE.      |                |        | RESIDUE ON EVAPORATION. |           |                 |                   |            |                 |  |  |  |
|---|---------|----------------------|-----------------------|------------------|----------------|--------|-------------------------|-----------|-----------------|-------------------|------------|-----------------|--|--|--|
|   |         | Collection,<br>1893. | Examination,<br>1893. | Turbidity.       | Sediment.      | Color. | TOTAL.                  |           |                 | LOSS ON IGNITION. |            |                 |  |  |  |
|   |         |                      |                       |                  |                |        | Total.                  | Dissolved | Sus-<br>pended. | Total.            | Dissolved. | Sus-<br>pended. |  |  |  |
|   |         | Sept.                | Sept.                 |                  |                |        |                         |           |                 |                   |            |                 |  |  |  |
| 1 | 15040   | 6                    | 7                     | Dec'd, milky.    | Slight, rusty. | .70    | 36.20                   | 35.20     | 1.00            | 5.80              | 5.60       | 0.20            |  |  |  |
| 2 | 15096   | 7                    | 9                     | Dec'd, rusty.    | Cons., rusty.  | .90    | 37.80                   | 34.60     | 3.20            | 3.60              | 3.40       | 0.20            |  |  |  |
| 3 | 15046   | 6                    | 7                     | Distinct, milky  | Slight, rusty. | .80    | 27.20                   | 25.60     | 1.60            | 6.00              | 6.40       | 0.20            |  |  |  |
| 4 | 15095   | 7                    | 9                     | Distinct, milky. | Cons., brown.  | .25    | 30.00                   | 25.80     | 4.20            | 4.60              | 3.80       | 0.90            |  |  |  |

Odor, offensive. — The first two samples were collected from the river at the outlet of Morse's Millbury. Each sample was made up of four equal portions, collected at intervals of three hours, as and 11.20 A. M., and 2.20 and 5.20 P. M.

*Chemical Examination of Water from the*  
[Parts per 100,000.]

|   | Number. | DATE OF —            |                       | APPEARANCE.      |                |        | RESIDUE ON EVAPORATION. |            |                 |                   |            |                 |
|---|---------|----------------------|-----------------------|------------------|----------------|--------|-------------------------|------------|-----------------|-------------------|------------|-----------------|
|   |         | Collection,<br>1893. | Examination,<br>1893. | Turbidity.       | Sediment.      | Color. | TOTAL.                  |            |                 | LOSS ON IGNITION. |            |                 |
|   |         |                      |                       |                  |                |        | Total.                  | Dissolved. | Sus-<br>pended. | Total.            | Dissolved. | Sus-<br>pended. |
| 1 | 15045   | Sept. 6              | Sept. 7               | Distinct, milky. | Slight, rusty. | .38    | 18.60                   | 18.00      | 0.60            | 4.00              | 3.80       | 0.20            |
| 2 | 15094   | 7                    | 9                     | Distinct, milky. | Slight, rusty. | .25    | 26.80                   | 24.60      | 2.20            | 4.60              | 4.20       | 0.40            |
| 3 | Av.     | .....                | .....                 | .....            | .....          | .32    | 22.70                   | 21.30      | 1.40            | 4.30              | 4.00       | 0.30            |

Odor, musty. — The samples were collected from the river, at the bridge on the road from Saun- was made up of four equal portions, collected at 9 A. M., 12 M., 3 P. M. and 6 P. M.

## BLACKSTONE RIVER.

*Dorothy and Cold Spring Brooks, at Millbury.*

[Parts per 100,000.]

| AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |           | OXYGEN CONSUMED. |           | Iron Oxide (Fe <sub>2</sub> O <sub>3</sub> ). | Lime (Ca O). | Sulphuric Acid (SO <sub>3</sub> ). |   |
|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|-----------|-----------------------------------------------|--------------|------------------------------------|---|
| Free.    | ALBUMINOID. |            |             |           | Nitrates.   | Nitrites. | Unfiltered.      | Filtered. |                                               |              |                                    |   |
|          | Total.      | Dissolved. | Sus-pended. |           |             |           |                  |           |                                               |              |                                    |   |
| .0140    | .0360       | .0280      | .0080       | .87       | .0000       | .0006     | 1.2870           | 1.2480    | .07                                           | .71          | .70                                | 1 |
| .0016    | .0580       | .0360      | .0220       | .43       | .0000       | .0001     | 1.6000           | 1.5210    | .14                                           | .55          | .97                                | 2 |
| .0006    | .0264       | .0204      | .0060       | .35       | .0000       | .0002     | 0.6694           | -         | .09                                           | .68          | .54                                | 3 |
| .0024    | .0282       | .0248      | .0034       | .33       | .0000       | .0001     | 0.5577           | -         | .06                                           | .69          | .52                                | 4 |
| .0324    | .0224       | .0188      | .0036       | .81       | .0100       | .0005     | 0.4820           | -         | .13                                           | .61          | .25                                | 5 |

first two samples were collected from Singletary Brook, about 100 feet above its mouth; the next two, the highway bridge not far from its mouth, at 8.10 A.M. Each sample, except the last, was made up of 2.00 and 4.55 P.M.; No. 18098, at 8.00 and 10.58 A.M., and 1.58 and 5.00 P.M.; No. 18042, at 8.40 and 11.40

*River above and below Millbury.*

[Parts per 100,000.]

| AMMONIA. |             |            |             | Chlorine. | NITROGEN AS |           | OXYGEN CONSUMED. |           | Iron Oxide (Fe <sub>2</sub> O <sub>3</sub> ). | Lime (Ca O). | Sulphuric Acid (SO <sub>3</sub> ). |   |
|----------|-------------|------------|-------------|-----------|-------------|-----------|------------------|-----------|-----------------------------------------------|--------------|------------------------------------|---|
| Free.    | ALBUMINOID. |            |             |           | Nitrates.   | Nitrites. | Unfiltered.      | Filtered. |                                               |              |                                    |   |
|          | TOTAL       | Dissolved. | Sus-pended. |           |             |           |                  |           |                                               |              |                                    |   |
| 0.7400   | .1160       | .0840      | .0320       | 3.63      | .0000       | .0003     | 1.5750           | 1.5000    | 1.28                                          | 8.82         | 12.63                              | 1 |
| 1.0620   | .0920       | .0670      | .0250       | 3.59      | .0000       | .0002     | 1.6990           | 1.1700    | 1.43                                          | 9.00         | 13.61                              | 2 |
| 0.7400   | .0800       | .0520      | .0280       | 2.74      | .0000       | .0200     | 1.1700           | 1.1700    | 0.43                                          | 6.46         | 8.57                               | 3 |
| 0.6100   | .0680       | .0510      | .0170       | 2.90      | .0000       | .0005     | 1.3650           | 1.1810    | 0.32                                          | 6.84         | 10.04                              | 4 |

mill-pond in Millbury; the last two samples, from the river about half a mile below the last dam in follows: the first two samples, at 8.55 and 11.50 A.M., and 2.55 and 5.55 P.M.; the last two samples, at 8.20

*Blackstone River, at Farnumsville.*

[Parts per 100,000.]

| AMMONIA. |             |            |                | Chlorine. | NITROGEN AS |           | OXYGEN CONSUMED. |           | Iron Oxide (Fe <sub>2</sub> O <sub>3</sub> ). | Lime (Ca O). | Sulphuric Acid (SO <sub>3</sub> ). |   |
|----------|-------------|------------|----------------|-----------|-------------|-----------|------------------|-----------|-----------------------------------------------|--------------|------------------------------------|---|
| Free.    | ALBUMINOID. |            |                |           | Nitrates.   | Nitrites. | Undiluted.       | Filtered. |                                               |              |                                    |   |
|          | Total.      | Dissolved. | Sus-<br>pended |           |             |           |                  |           |                                               |              |                                    |   |
| .6380    | .0460       | .0400      | .0060          | 2.47      | .0020       | .0012     | 1.2870           | 1.1700    | .02                                           | 5.38         | 7.22                               | 1 |
| .5940    | .0490       | .0400      | .0090          | 2.43      | .0050       | .0150     | 1.0630           | 0.9360    | .16                                           | 5.70         | 8.41                               | 2 |
| .6150    | .0475       | .0400      | .0075          | 2.45      | .0035       | .0081     | 1.1700           | 1.0630    | .09                                           | 5.54         | 7.82                               | 3 |

dersville to Grafton, above the confluence of the Blackstone and Quinsigamond rivers. Each sample



## BLACKSTONE RIVER.

*Chemical Examination of Water from the*

[Parts per 100,000.]

|   | Number. | DATE OF —            |                       | APPEARANCE.  |              |        | RESIDUE ON EVAPORATION. |            |             |                   |            |             |
|---|---------|----------------------|-----------------------|--------------|--------------|--------|-------------------------|------------|-------------|-------------------|------------|-------------|
|   |         | Collection,<br>1895. | Examination,<br>1895. | Turbidity.   | Sediment.    | Color. | TOTAL.                  |            |             | LOSS ON IGNITION. |            |             |
|   |         |                      |                       |              |              |        | Total.                  | Dissolved. | Sus-pended. | Total.            | Dissolved. | Sus-pended. |
| 1 | 15044   | Sept. 8              | Sept. 7               | Very slight. | Very slight. | .35    | 4.50                    | —          | —           | 1.50              | —          | —           |
| 2 | 15009   | 7                    | 9                     | Very slight. | Slight.      | .33    | 5.20                    | 4.90       | 0.30        | 1.60              | 1.40       | 0.20        |
| 3 | Av.     | .....                | .....                 | .....        | .....        | .34    | 4.85                    | —          | —           | 1.55              | —          | —           |

Odor, vegetable. — The samples were collected from the Quinsigamond River, at the bridge on the sample was made up of four equal portions, collected at 9 A.M., 12 M., 3 P.M. and 6 P.M.

*Chemical Examination of Water from*

[Parts per 100,000.]

|   | Number. | DATE OF —            |                       | APPEARANCE. |                |        | RESIDUE ON EVAPORATION. |                   |
|---|---------|----------------------|-----------------------|-------------|----------------|--------|-------------------------|-------------------|
|   |         | Collection,<br>1895. | Examination,<br>1895. | Turbidity.  | Sediment.      | Color. | Total.                  | Loss on Ignition. |
|   |         |                      |                       |             |                |        |                         |                   |
| 1 | 14976   | Sept. 4              | Sept. 5               | Slight.     | Slight.        | .18    | 14.50                   | 4.20              |
| 2 | 15002   | 5                    | 6                     | Distinct.   | Slight, rusty. | .20    | 15.30                   | 2.90              |
| 3 | 15027   | 6                    | 7                     | Slight.     | Slight.        | .20    | 15.70                   | 3.60              |
| 4 | 15078   | 7                    | 9                     | Slight.     | Slight, brown. | .18    | 16.90                   | 3.50              |
| 5 | 15082   | 7                    | 9                     | Slight.     | Slight.        | .18    | 17.30                   | 3.80              |
| 6 | 15124   | 9                    | 10                    | Slight.     | Slight.        | .15    | 17.40                   | 3.40              |
| 7 | 15149   | 10                   | 11                    | Slight.     | Slight, brown. | .20    | 18.40                   | 4.50              |
| 8 | Av.     | .....                | .....                 | .....       | .....          | .18    | 16.50                   | 3.70              |

Odor, vegetable or musty. — The samples were collected from the lower end of the canal leading one being collected at about 9 A.M., and one at about 3 P.M.

## BLACKSTONE RIVER.

*Quinsigamond River, at Farnumsville.*

[Parts per 100,000.]

| AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Iron Oxide (Fe <sub>2</sub> O <sub>3</sub> ). | Lime (Ca O). | Sulphuric Acid (SO <sub>3</sub> ). |   |
|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------------------------------------------|--------------|------------------------------------|---|
| Free.    | ALBUMINOID. |            |                 |           | Nitrates.   | Nitrites. |                  |                                               |              |                                    |   |
|          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |                                               |              |                                    |   |
| .0004    | .0238       | .0224      | .0014           | .35       | .0040       | .0002     | .4602            | .02                                           | .71          | .35                                | 1 |
| .0020    | .0226       | .0196      | .0030           | .36       | .0000       | .0001     | .4313            | .03                                           | .67          | .39                                | 2 |
| .0012    | .0232       | .0210      | .0022           | .36       | .0020       | .0002     | .4458            | .03                                           | .69          | .37                                | 3 |

road from Saundersville to Grafton, about a mile above its confluence with the Blackstone River. Each.

*the Blackstone River, at Uxbridge.*

[Parts per 100,000 ]

| AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen consumed. | Iron (Fe <sub>2</sub> O <sub>3</sub> ). | Lime (Ca. O ). | Sulphuric Acid(SO <sub>3</sub> ). |   |
|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------------------------------------|----------------|-----------------------------------|---|
| Free.    | ALBUMINOID. |            |                 |           | Nitrates.   | Nitrites. |                  |                                         |                |                                   |   |
|          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |                                         |                |                                   |   |
| .0445    | .0185       | .0145      | .0040           | 1.68      | .1000       | .0055     | .3249            | -                                       | -              | -                                 | 1 |
| .0816    | .0260       | .0204      | .0056           | 1.71      | .0850       | .0100     | .3681            | -                                       | -              | -                                 | 2 |
| .1120    | .0244       | .0184      | .0060           | 1.76      | .0700       | .0100     | .3884            | -                                       | -              | -                                 | 3 |
| .0996    | .0268       | .0216      | .0052           | 1.87      | .0600       | .0080     | .3432            | -                                       | -              | -                                 | 4 |
| .1028    | .0224       | .0184      | .0040           | 1.78      | .0600       | .0060     | .3660            | -                                       | -              | -                                 | 5 |
| .1184    | .0196       | .0152      | .0044           | 1.78      | .0850       | .0055     | .3744            | -                                       | -              | -                                 | 6 |
| .1040    | .0184       | .0180      | .0004           | 1.80      | .0650       | .0000     | .3884            | -                                       | -              | -                                 | 7 |
| .0947    | .0223       | .0181      | .0042           | 1.75      | .0750       | .0064     | .3648            | .07*                                    | 3.44*          | 4.07*                             | 8 |

from the upper dam of the Calumet Woolen Company. Each sample was made up of two equal portions,

\* These determinations were made upon a mixture of equal parts of water from each of the samples.

**BLACKSTONE RIVER.***Chemical Examination of Water from*

[Parts per 100,000.]

|   | Number. | DATE OF—             |                       | APPEARANCE. |                 |        | RESIDUE ON EVAPO-<br>RATION. |                      |
|---|---------|----------------------|-----------------------|-------------|-----------------|--------|------------------------------|----------------------|
|   |         | Collection,<br>1895. | Examination,<br>1895. | Turbidity.  | Sediment.       | Color. | Total.                       | Loss on<br>Ignition. |
| 1 | 15004   | Sept.<br>5           | Sept.<br>6            | Distinct.   | Slight, yellow. | .45    | 2.80                         | 0.60                 |
| 2 | 15080   | 7                    | 9                     | Distinct.   | Cons., brown.   | .43    | 3.85                         | 1.15                 |
| 3 | Av..... | .....                | .....                 | .....       | .....           | .44    | 3.33                         | 0.88                 |

Odor, musty. — The samples were collected from the Mumford River, at a point near the iron the confluence of the Mumford and Blackstone rivers. The samples were collected at about 3 P M.

*Chemical Examination of Water from*

[Parts per 100,000.]

|   | Number. | DATE OF—             |                       | APPEARANCE. |           |        | RESIDUE ON EVAPO-<br>RATION. |                      |
|---|---------|----------------------|-----------------------|-------------|-----------|--------|------------------------------|----------------------|
|   |         | Collection,<br>1895. | Examination,<br>1895. | Turbidity.  | Sediment. | Color. | Total.                       | Loss on<br>Ignition. |
| 1 | 15003   | Sept.<br>5           | Sept.<br>6            | Distinct.   | Slight.   | .40    | 4.20                         | 1.00                 |
| 2 | 15081   | 7                    | 9                     | Distinct.   | Slight.   | .40    | 4.50                         | 1.65                 |
| 3 | Av..... | .....                | .....                 | .....       | .....     | .40    | 4.35                         | 1.63                 |

Odor, vegetable and musty. — The samples were collected from the West River, below the last

## BLACKSTONE RIVER.

*the Mumford River, at Uxbridge.*

[Parts per 100,000.]

| AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Iron (Fe <sub>2</sub> O <sub>3</sub> ). | Lime (Ca O). | Sulphuric Acid (SO <sub>3</sub> ). |   |
|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------------------------------------|--------------|------------------------------------|---|
| Free.    | ALBUMINOID. |            |                 |           | Nitrates.   | Nitrites. |                  |                                         |              |                                    |   |
|          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |                                         |              |                                    |   |
| .0004    | .0220       | .0158      | .0062           | .33       | .0000       | .0002     | .3861            | .11                                     | .36          | .28                                | 1 |
| .0024    | .0214       | .0178      | .0036           | .33       | .0000       | .0001     | .3627            | .24                                     | .69          | .22                                | 2 |
| .0014    | .0217       | .0168      | .0049           | .33       | .0000       | .0002     | .3744            | .18                                     | .53          | .25                                | 3 |

bridge, on the road to the freight depot, just below Capron's Mill, and about three-eighths of a mile above

*the West River, at Uxbridge.*

[Parts per 100,000.]

| AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Iron (Fe Os). | Lime (Ca O). | Sulphuric Acid (SO <sub>3</sub> ) |   |
|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|---------------|--------------|-----------------------------------|---|
| Free.    | ALBUMINOID. |            |                 |           | Nitrates.   | Nitrites. |                  |               |              |                                   |   |
|          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |               |              |                                   |   |
| .0030    | .0234       | .0226      | .0008           | .34       | .0000       | .0003     | .5819            | .10           | .51          | .20                               | 1 |
| .0028    | .0290       | .0246      | .0044           | .34       | .0000       | .0004     | .5832            | .16           | .97          | .18                               | 2 |
| .0029    | .0262       | .0236      | .0026           | .34       | .0000       | .0004     | .5851            | .18           | .74          | .19                               | 3 |

bridge on the stream, which is a little less than half a mile above its mouth, at about 3.30 P.M.

**BLACKSTONE RIVER.***Chemical Examination of Water from the Blackstone River, at Millville, Blackstone.*

[Parts per 100,000.]

| Number. | DATE OF —            |                       | APPEARANCE.  |               |        | RESIDUE ON EVAPORATION. |                   |
|---------|----------------------|-----------------------|--------------|---------------|--------|-------------------------|-------------------|
|         | Collection,<br>1895. | Examination,<br>1895. | Turbidity.   | Sediment.     | Color. | Total.                  | Loss on Ignition. |
| 14975   | Sept. 4              | Sept. 5               | Slight.      | Slight.       | .20    | 9.70                    | 2.40              |
| 15001   | 5                    | 6                     | Slight.      | Slight.       | .22    | 10.40                   | 2.50              |
| 15028   | 6                    | 7                     | Very slight. | Slight.       | .25    | 11.50                   | 2.50              |
| 15079   | 7                    | 9                     | Slight.      | Cons., brown. | .25    | 11.30                   | 2.30              |
| 15104   | 9                    | 10                    | Slight.      | Slight.       | .35    | 10.60                   | 1.80              |
| 15148   | 10                   | 11                    | Distinct.    | Slight.       | .20    | 11.40                   | 3.60              |
| 15157   | 11                   | 12                    | Slight.      | Slight.       | .25    | 10.60                   | 2.50              |
| Av..... | .....                | .....                 | .....        | .....         | .25    | 10.79                   | 2.51              |

*Chemical Examination of Water from the Blackstone River, at Millville, Blackstone*  
— Concluded.

[Parts per 100,000.]

| Number. | AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Iron (Feg O <sub>2</sub> ). | Lime (Ca O). | Sulphuric Acid (SO <sub>3</sub> ). |
|---------|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|-----------------------------|--------------|------------------------------------|
|         | Free.    | ALBUMINOID. |            |                 |           | Nitrates.   | Nitrites. |                  |                             |              |                                    |
|         |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |                             |              |                                    |
| 14975   | .0174    | .0210       | .0194      | .0016           | 1.10      | .0600       | .0013     | .3064            | -                           | -            | -                                  |
| 15001   | .0161    | .0230       | .0180      | .0050           | 1.10      | .0180       | .0018     | .3822            | -                           | -            | -                                  |
| 15028   | .0170    | .0192       | .0192      | .0000           | 1.02      | .0480       | .0020     | .4095            | -                           | -            | -                                  |
| 15079   | .0426    | .0225       | .0196      | .0032           | 1.18      | .0520       | .0020     | .3572            | -                           | -            | -                                  |
| 15104   | .0380    | .0188       | .0166      | .0022           | 1.13      | .0400       | .0020     | .3962            | -                           | -            | -                                  |
| 15148   | .0380    | .0208       | .0164      | .0044           | 1.28      | .0500       | .0018     | .3822            | -                           | -            | -                                  |
| 15157   | .0394    | .0180       | .0154      | .0026           | 1.10      | .0300       | .0015     | .3884            | -                           | -            | -                                  |
| Av.     | .0298    | .0205       | .0178      | .0027           | 1.13      | .0426       | .0018     | .3746            | *.08                        | *2.06        | *2.41                              |

\* These determinations were made upon a mixture of equal parts of water from all the samples.

Odor, musty. — The samples were collected from the river, just above the bridge, in the village of Millville. Each sample was made up of two equal portions, one being collected at 9 A.M., and one at 3 P.M.

## CHARLES RIVER.

## CHARLES RIVER.

*Chemical Examination of Water from the Charles River at Milford.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.      | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
|         | 1895.               |             |                |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 15684   | Dec. 4              | V. slight.  | Slight.        | .80    | 3.10                    | 1.80              | .0000    | .0156       | .0140      | .0016      | .20       | .0050       | .0000     | .7114            | 0.8       |
| 15683   | Dec. 4              | Decided.    | Cons., earthy. | .85    | 3.45                    | 2.35              | .0390    | .0314       | .0258      | .0056      | .49       | .0470       | .0014     | .7691            | 1.7       |

Odor of the first sample, faintly vegetable; of the last, distinctly vegetable and musty. — The first sample was collected at the dam opposite the pumping station of the Milford Water Company; the last, at the railroad bridge half a mile below Milford.

The samples were collected in connection with an investigation of the pollution of the stream by sewage from Milford.

## CRANE'S RIVER.

*Chemical Examination of Water from Crane's River, Danvers.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                 |        | RESIDUE ON EVAPORATION. |                   |
|---------|---------------------|------------------|-----------------|--------|-------------------------|-------------------|
|         |                     | Turbidity.       | Sediment.       | Color. | Total.                  | Loss on Ignition. |
|         | 1895.               |                  |                 |        |                         |                   |
| 15680   | Nov. 12             | V. slight.       | Slight.         | 0.60   | 7.00                    | 2.70              |
| 15682   | Nov. 12             | Decided.         | Cons., brown.   | 10.00  | 27.80                   | 9.80              |
| 15683   | Nov. 12             | Decided.         | Slight.         | 2.50   | 40.90                   | 9.00              |
| 15620   | Nov. 12             | Slight.          | Slight.         | 0.60   | 3347.00                 | -                 |
| 15584   | Nov. 12             | Decided.         | Slight.         | 2.40   | 85.80                   | 22.40             |
| 15619   | Nov. 12             | Slight, white.   | Slight, earthy. | 0.13   | 3349.00                 | -                 |
| 15635   | Nov. 12             | Distinct, brown. | Slight, earthy. | 0.40   | 2892.00                 | -                 |

*Chemical Examination of Water from Crane's River, Danvers — Concluded.*

[Parts per 100,000.]

| Number. | AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen<br>Consumed. | Hard-<br>ness. |
|---------|----------|-------------|------------|-----------------|-----------|-------------|-----------|---------------------|----------------|
|         | Free.    | ALBUMINOID. |            |                 |           | Nitrates.   | Nitrites. |                     |                |
|         |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                     |                |
| 15530   | .0000    | .0218       | .0208      | .0010           | 0.98      | .0200       | .0000     | 0.6357              | 2.7            |
| 15532   | .0720    | .1480       | .1140      | .0340           | 57.50     | .0250       | .0008     | 4.6800              | 6.0            |
| 15583   | .0410    | .0720       | .0520      | .0200           | 15.95     | .0250       | .0060     | 1.7160              | 9.0            |
| 15520   | .0316    | .0236       | .0184      | .0052           | 1245.00   | .0080       | .0025     | 2.4024              | -              |
| 15584   | .0470    | .0720       | .0490      | .0230           | 88.50     | .0130       | .0060     | 1.7550              | 19.0           |
| 15519   | .0204    | .0176       | .0096      | .0080           | 1619.00   | .0050       | .0020     | 3.2370              | -              |
| 15535   | .0308    | .0280       | .0228      | .0062           | 1295.00   | .0020       | .0030     | 2.4960              | -              |

Odor of the first sample, none, becoming distinctly vegetable on heating; of the second, disagreeable; of the third and fifth, distinct of manufacturing waste; of the fourth and sixth, faintly musty; of the last, unpleasant. — The samples were collected as follows: No. 15580 from Crane's Brook at the point where it is crossed by the railroad at Tapleyville and above factories in Danvers; No. 15532 from Crane's Brook about 1,000 feet below tannery; No. 15533 from Crane's Pond at the railroad bridge near the lower end; Nos. 15520 and 15534 from Crane's River just below dam at tide mill, the first when the tide was half out and the last at low tide; Nos. 15519 and 15535 from the Essex Branch River below Danversport, the first when the tide was half out and the last at low tide.

These samples were collected in connection with an investigation of the pollution of the stream by manufacturing refuse.

**CRANE'S RIVER.***Chemical Examination of Manufacturing Sewage from Morocco Shops in Danvers.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |              | RESIDUE ON EVAPORATION. |            |             |                   |            |             |
|---------|---------------------|-------------|--------------|-------------------------|------------|-------------|-------------------|------------|-------------|
|         |                     | Turbidity.  | Sediment.    | TOTAL RESIDUE.          |            |             | LOSS ON IGNITION. |            |             |
|         |                     |             |              | Total.                  | Dissolved. | Sus-pended. | Total.            | Dissolved. | Sus-pended. |
| 15531   | 1895.<br>Nov. 12    | Opaque.     | Dark, brown. | 445.0                   | 354.2      | 90.8        | 190.6             | 113.6      | 77.0        |

*Chemical Examination of Manufacturing Sewage from Morocco Shops in Danvers — Concluded.*

[Parts per 100,000.]

| Number. | AMMONIA. |             |            |             | Chlorine. | OXYGEN CONSUMED. |           | IRON.       |           |
|---------|----------|-------------|------------|-------------|-----------|------------------|-----------|-------------|-----------|
|         | Free.    | ALBUMINOID. |            |             |           | Unfiltered.      | Filtered. | Unfiltered. | Filtered. |
|         |          | Total.      | Dissolved. | Sus-pended. |           |                  |           |             |           |
| 15331   | 1.3600   | 4.3400      | 2.2200     | 2.1200      | 102.5     | 141.96           | 79.56     | .5100       | .1800     |

Odor, offensive. — The sample was collected from a drain discharging sewage from three morocco shops into Crane's River.

This analysis was made in connection with an investigation of the pollution of the stream by manufacturing sewage.

## DEERFIELD RIVER.

## DEERFIELD RIVER.

*Chemical Examination of Water from the Deerfield River above Shelburne Falls.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                   |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |                 | NITROGEN AS |           | Oxygen Consumed. | Hardness. |           |
|---------|---------------------|-------------|-------------------|--------|-------------------------|-------------------|----------|-------------|------------|-----------------|-------------|-----------|------------------|-----------|-----------|
|         |                     | Turbidity.  | Sediment.         | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |                 | Chlorine.   | Nitrates. |                  |           | Nitrites. |
|         |                     |             |                   |        |                         |                   |          | Total.      | Dissolved. | Sus-<br>pended. |             |           |                  |           |           |
| 1895.   |                     |             |                   |        |                         |                   |          |             |            |                 |             |           |                  |           |           |
| 13673   | Jan. 14             | V. slight.  | V. slight.        | .25    | 2.90                    | 0.95              | .0002    | .0088       | .0074      | .0014           | .10         | .0120     | .0000            | .3397     | 1.6       |
| 13751   | Feb. 4              | V. slight.  | V. slight.        | .20    | 3.50                    | 0.85              | .0012    | .0082       | .0070      | .0012           | .12         | .0180     | .0000            | .2528     | 1.8       |
| 13987   | Mar. 15             | V. slight.  | Slight.           | .15    | 3.35                    | 0.70              | .0004    | .0062       | .0046      | .0016           | .12         | .0120     | .0000            | .2275     | 2.2       |
| 14075   | Apr. 1              | V. slight.  | Cons.,<br>white.  | .12    | 3.75                    | 1.10              | .0002    | .0056       | .0042      | .0014           | .10         | .0270     | .0000            | .1848     | 1.8       |
| 14232   | May 1               | V. slight.  | Slight.           | .32    | 2.95                    | 1.45              | .0000    | .0112       | .0084      | .0028           | .08         | .0050     | .0001            | .4504     | 1.1       |
| 14420   | June 3              | Slight.     | Slight,<br>rusty. | .17    | 4.20                    | 1.20              | .0046    | .0169       | .0146      | .0020           | .16         | .0030     | .0000            | .3230     | 1.9       |
| 14575   | July 2              | Slight.     | Slight.           | .33    | 3.45                    | 0.95              | .0010    | .0178       | .0146      | .0032           | .08         | .0000     | .0001            | .5348     | 1.9       |
| 14768   | Aug. 5              | V. slight.  | Slight.           | .80    | 4.20                    | 1.70              | .0006    | .0188       | .0172      | .0016           | .08         | .0120     | .0001            | .9633     | 1.9       |
| 14964   | Sept. 3             | V. slight.  | V. slight.        | .28    | 4.20                    | 1.00              | .0002    | .0118       | .0080      | .0038           | .14         | .0000     | .0001            | .4196     | 1.8       |
| 15295   | Oct. 1              | Slight.     | Slight.           | .40    | 4.10                    | 1.70              | .0008    | .0148       | .0136      | .0012           | .14         | .0030     | .0000            | .5288     | 1.7       |
| 15482   | Nov. 5              | V. slight.  | Slight.           | .40    | 3.60                    | 1.30              | .0004    | .0118       | .0088      | .0030           | .10         | .0140     | .0001            | .5834     | 1.4       |
| 15682   | Dec. 3              | Distinct    | Cons.             | .40    | 2.95                    | 1.15              | .0000    | .0128       | .0088      | .0040           | .04         | .0070     | .0000            | .5733     | 0.9       |
| Av.     | .....               | .....       | .....             | .32    | 3.60                    | 1.17              | .0008    | .0120       | .0097      | .0023           | .10         | .0097     | .0000            | .4454     | 1.7       |

Odor, faintly vegetable or none. — The samples were collected from the river about a mile above the bridge in the village of Shelburne Falls.

## FRENCH RIVER.

*Chemical Examination of Water from French River and its Tributaries in Webster.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |              | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|--------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |              |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Sus- pended. |           |             |           |                  |           |
| 1895.   |                     |             |           |        |                         |                   |          |             |            |              |           |             |           |                  |           |
| 15604   | Nov. 22             | Slight.     | Slight.   | .97    | 4.20                    | 2.05              | .0006    | .0194       | .0166      | .0028        | .21       | .0070       | .0001     | 0.9009           | 0.8       |
| 15603   | Nov. 22             | Distinct.   | Slight.   | .30    | 6.70                    | 2.45              | .0010    | .0224       | .0164      | .0060        | .27       | .0030       | .0000     | 0.6318           | 2.3       |
| 15602   | Nov. 22             | Distinct.   | Slight.   | .60    | 6.95                    | 2.70              | .0010    | .0520       | .0424      | .0096        | .70       | .0030       | .0001     | 0.9298           | 1.7       |
| 15605   | Nov. 22             | Decided.    | Slight.   | .95    | 5.25                    | 2.40              | .0006    | .0324       | .0266      | .0058        | .31       | .0070       | .0002     | 1.0374           | 1.1       |

Odor of the first sample, distinctly vegetable; of the second, distinctly vegetable and disagreeable; of the third, distinctly tarry; of the last, decidedly tarry. — The first sample was collected from French River above Webster, just above the mouth of Mill Brook; the second, from Mill Brook, near its confluence with French River; the third, from a brook entering French River just below Merino Village in Dudley; the last, from French River at the first railroad bridge over the river below the line between Massachusetts and Connecticut.

These samples were collected in connection with an investigation relative to a proposed system of sewerage and sewage disposal for the town of Webster.



## HOOSAC RIVER.

## HOOSAC RIVER.

*Chemical Examination of Water from the Hoosac River at Williamstown.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                    |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|--------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.          | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |                    |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 13591   | 1895.<br>Jan. 2     | Distinct.   | Slight,<br>clayey. | .30    | 12.30                           | 2.90                 | .0190    | .0248       | .0208      | .0040           | 0.35      | .0220          | .0004     | .4158            | 8.6       |
| 13674   | Jan. 15             | Distinct.   | Slight,<br>milky.  | .20    | 8.00                            | 1.60                 | .0086    | .0192       | .0140      | .0052           | 0.25      | .0300          | .0001     | .2528            | 6.1       |
| 13848   | Feb. 19             | Distinct.   | Slight,<br>white.  | .20    | 13.50                           | 2.90                 | .0194    | .0272       | .0220      | .0052           | 0.49      | .0230          | .0009     | .5460            | 8.6       |
| 14022   | Mar. 20             | Distinct.   | Cons.,<br>gray.    | .25    | 11.40                           | 2.60                 | .0146    | .0226       | .0156      | .0040           | 0.33      | .0100          | .0007     | .4740            | 7.6       |
| 14160   | Apr. 16             | Distinct.   | Cons.<br>gray.     | .20    | 6.40                            | 3.15                 | .0020    | .0252       | .0158      | .0094           | 0.18      | .0350          | .0003     | .4898            | 2.9       |
| 14356   | May 21              | Distinct.   | Cons.              | .20    | 11.65                           | 2.80                 | .0002    | .0264       | .0158      | .0106           | 0.34      | .0150          | .0010     | .3078            | 8.4       |
| 14519   | June 20             | Distinct.   | Cons.,<br>rusty.   | .28    | 14.00                           | 4.00                 | .0086    | .0192       | .0104      | .0088           | 0.52      | .0080          | .0042     | .4158            | 9.4       |
| 14716   | July 24             | Distinct.   | Cons.,<br>dark.    | .30    | 17.70                           | 1.90                 | .0464    | .0676       | .0344      | .0332           | 0.86      | .0050          | .0011     | .4889            | 12.6      |
| 14895   | Aug. 20             | Distinct.   | Heavy,<br>dirty.   | .28    | 15.55                           | 3.65                 | .0140    | .0576       | .0216      | .0360           | 0.74      | .0050          | .0020     | .5382            | 9.7       |
| 15196   | Sept. 17            | Slight.     | Cons.,<br>rusty.   | .35    | 18.25                           | 3.50                 | .0342    | .0454       | .0338      | .0116           | 1.00      | .0030          | .0030     | .5382            | 10.7      |
| 15389   | Oct. 15             | Distinct.   | Slight,<br>milky.  | .60    | 11.30                           | 3.60                 | .0016    | .0352       | .0254      | .0098           | 0.34      | .0180          | .0012     | .8330            | 6.4       |
| 15588   | Nov. 19             | Slight.     | Cons.<br>rusty.    | .25    | 8.40                            | 2.90                 | .0090    | .0296       | .0190      | .0106           | 0.32      | .0150          | .0003     | .3432            | 5.4       |
| 15763   | Dec. 17             | Distinct.   | Slight,<br>milky.  | .18    | 10.65                           | 2.10                 | .0112    | .0234       | .0142      | .0092           | 0.28      | .0320          | .0005     | .2618            | 7.7       |
| Av.*    | .....               | .....       | .....              | .23    | 12.41                           | 2.95                 | .0146    | .0334       | .0207      | .0127           | 0.39      | .0162          | .0013     | .4642            | 8.1       |

*Averages by Years.*

|   |       |   |   |     |       |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|-------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887† | - | - | .21 | 11.50 | 1.23 | .0057 | .0178 | -     | -     | .22 | .0239 | -     | -     | -   |
| - | 1888  | - | - | .10 | 10.21 | 1.65 | .0040 | .0187 | .0143 | .0044 | .24 | .0306 | .0010 | -     | -   |
| - | 1889† | - | - | .08 | 8.74  | 1.13 | .0071 | .0162 | .0104 | .0058 | .18 | .0254 | .0006 | -     | -   |
| - | 1894  | - | - | .23 | 10.77 | 2.13 | .0111 | .0265 | .0169 | .0096 | .35 | .0157 | .0009 | .3421 | 7.3 |
| - | 1895  | - | - | .28 | 12.41 | 2.95 | .0146 | .0334 | .0207 | .0127 | .39 | .0162 | .0013 | .5301 | 8.1 |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

† June to December.

‡ January to May.

NOTE to analyses of 1895: Odor, generally decidedly musty, frequently also disagreeable. — The samples were collected from the river at the bridge near the Williamstown station on the Fitchburg Railroad.

## HOUSATONIC RIVER.

## HOUSATONIC RIVER.

*Chemical Examination of Water from the Housatonic River at New Lenox.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | NITROGEN AS |           | Oxygen Consumed. | Hardness. |           |
|---------|---------------------|-------------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-------------|-----------|------------------|-----------|-----------|
|         |                     | Turbidity.        | Sediment.       | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            | Chlorine.   | Nitrates. |                  |           | Nitrites. |
|         |                     |                   |                 |        |                         |                   |          | Total.      | Dissolved. | Suspended. |             |           |                  |           |           |
| 13703   | 1895.<br>Jan. 22    | Distinct, milky.  | Cons., gray.    | .10    | 10.90                   | 1.95              | .0114    | .0182       | .0146      | .0036      | .23         | .0150     | .0005            | .3381     | 8.3       |
| 13855   | Feb. 19             | Distinct.         | Slight.         | .30    | 12.90                   | 1.80              | .0210    | .0200       | .0158      | .0042      | .24         | .0150     | .0009            | .3939     | 8.7       |
| 14045   | Mar. 26             | Distinct, clayey. | Cons., dark.    | .25    | 9.60                    | 2.10              | .0082    | .0264       | .0178      | .0086      | .17         | .0170     | .0003            | .3965     | 7.5       |
| 14214   | Apr. 25             | Slight.           | Cons.           | .23    | 8.55                    | 2.00              | .0002    | .0144       | .0112      | .0032      | .12         | .0170     | .0003            | .3311     | 6.4       |
| 14518   | June 20             | Distinct.         | Cons., rusty.   | .20    | 10.85                   | 2.70              | .0228    | .0250       | .0192      | .0058      | .23         | .0050     | .0020            | .3696     | 7.9       |
| 14653   | July 18             | Slight.           | Cons.           | .28    | 11.40                   | 2.00              | .0182    | .0234       | .0206      | .0028      | .27         | .0080     | .0100            | .4050     | 8.6       |
| 14937   | Aug. 29             | Distinct.         | Slight, rusty.  | .20    | 13.65                   | 3.55              | .0232    | .0234       | .0182      | .0052      | .36         | .0120     | .0110            | .3900     | 9.4       |
| 15205   | Sept. 17            | Distinct.         | Slight.         | .18    | 15.40                   | 2.55              | .0364    | .0232       | .0210      | .0022      | .37         | .0250     | .0100            | .3533     | 10.3      |
| 15378   | Oct. 16             | Slight.           | Cons., fibrous. | .63    | 11.80                   | 3.60              | .0132    | .0374       | .0278      | .0096      | .30         | .0270     | .0020            | .8775     | 7.6       |
| 15749   | Dec. 17             | Distinct.         | Cons.           | .27    | 12.30                   | 2.80              | .0280    | .0268       | .0172      | .0096      | .25         | .0320     | .0015            | .4235     | 9.2       |
| Av.     | .....               | .....             | .....           | .26    | 11.73                   | 2.50              | .0183    | .0238       | .0183      | .0055      | .25         | .0173     | .0038            | .4278     | 8.4       |

*Averages by Years.*

|   |       |   |   |     |       |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|-------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1893* | - | - | .30 | 9.73  | 2.21 | .0068 | .0174 | .0134 | .0040 | .16 | .0175 | .0014 | .4180 | 7.0 |
| - | 1894  | - | - | .27 | 11.37 | 2.13 | .0181 | .0183 | .0144 | .0039 | .25 | .0204 | .0024 | .3512 | 8.5 |
| - | 1895  | - | - | .26 | 11.73 | 2.50 | .0183 | .0238 | .0183 | .0055 | .25 | .0173 | .0038 | .4278 | 8.4 |

\* March to December.

NOTE to analyses of 1895: Odor, musty. — The samples were collected from the river.

## MERRIMACK RIVER.

The usual monthly examinations of the water of this river opposite the intakes of the Lowell and the Lawrence Water Works have been continued during 1895, the detailed results of which may be found on pages 204 and 191 of this volume. A comparison of the analyses made at these two places during the year is given in the following table: —

**MERRIMACK RIVER.**

*Table comparing the Analyses above Lowell with those above Lawrence, 1895.*

[Parts per 100,000.]

|                                                   | Color. | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Hardness. |
|---------------------------------------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|-----------|
|                                                   |        | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |           |
|                                                   |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |           |
| Number of determinations com-<br>pared, . . . . . | 11     | 11                              | 11                   | 11       | 11          | 11         | 11              | 11        | 11             | 11        | 11        |
| Mean of analyses above Lowell,                    | .41    | 3.84                            | 1.46                 | .0039    | .0187       | .0140      | .0047           | .212      | .0066          | .0001     | 1.2       |
| Mean of analyses above Law-<br>rence, . . . . .   | .52    | 4.36                            | 1.79                 | .0061    | .0250       | .0186      | .0064           | .275      | .0071          | .0002     | 1.3       |
| Increase, . . . . .                               | .11    | 0.52                            | 0.33                 | .0022    | .0063       | .0046      | .0017           | .063      | .0005          | .0001     | 0.1       |

In order to compare these results with similar ones obtained in previous years, another table is presented, which contains the increase in impurities as the water passes from a point above Lowell to Lawrence, as given in the last line of the above table, and the corresponding increase in previous years:—

*Increase in the Amount of Impurities in the Merrimack River Water, from a Point above Lowell to Lawrence, as determined by the Regular Monthly Examinations of Different Years.*

[Parts per 100,000.]

| DATE.                  | Color. | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Hardness. |
|------------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|-----------|
|                        |        | Total.                          | Loss on<br>ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |           |
|                        |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |           |
| Increase, 1887-1890, . | 0.01   | 0.23                            | 0.09                 | .0007    | .0027       | .0017      | .0009           | .026      | .0003*         | .0000     | -         |
| Increase, 1890, . .    | 0.05   | 0.62                            | 0.22*                | .0016    | .0023       | .0017      | .0006           | .028      | .0020*         | .0000     | 0.2       |
| Increase, 1891, . .    | 0.02*  | 0.29                            | 0.07                 | .0021    | .0023       | .0021      | .0002           | .035      | .0030*         | .0000     | 0.1       |
| Increase, 1892, . .    | 0.06   | 0.48                            | 0.12                 | .0019    | .0037       | .0037      | .0000           | .039      | .0013*         | .0000     | 0.0       |
| Increase, 1893, . .    | 0.09   | 0.47                            | 0.30                 | .0031    | .0032       | .0021      | .0011           | .035      | .0002*         | .0001     | 0.0       |
| Increase, 1894, . .    | 0.02   | 0.15                            | 0.04                 | .0028    | .0032       | .0032      | .0000           | .049      | .0000          | .0000     | 0.1       |
| Increase, 1895, . .    | 0.11   | 0.52                            | 0.33                 | .0022    | .0063       | .0046      | .0017           | .063      | .0005          | .0001     | 0.1       |

\* Decrease.

The average flow of the river at Lawrence, for twenty-four hours, during the days on which samples were collected, was for the above periods, respectively, at the rate of 9,148, 9,948, 7,931, 5,433, 8,126, 5,459 and 11,634 cubic feet per second.

## MERRIMACK RIVER.

*Chemical Examination of Water from the Merrimack River above Lowell, opposite the Intake of the Lowell Water Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                    |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|--------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.          | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                    |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 14654   | 1895.<br>July 22    | Distinct.   | Cons.              | .33    | 4.40                    | 1.85              | .0024    | .0202       | .0148      | .0054      | .23       | .0080       | .0004     | .4950            | 1.4       |
| 14655   | July 22             | Slight.     | Cons.              | .33    | 4.30                    | 1.90              | .0024    | .0196       | .0162      | .0034      | .22       | .0080       | .0004     | .4725            | 1.4       |
| 15244   | Sept. 24            | Slight.     | Slight,<br>earthy. | .22    | 3.80                    | 1.30              | .0048    | .0178       | .0154      | .0024      | .27       | .0070       | .0002     | .3432            | 1.1       |
| 15245   | Sept. 24            | Slight.     | Slight,<br>earthy. | .22    | 3.80                    | 1.15              | .0052    | .0206       | .0130      | .0056      | .26       | .0160       | .0002     | .3136            | 1.1       |

Odor, vegetable. — The first and third samples were collected from the north half of the river; the second and last, from the south half.

*Chemical Examination of Water from the Merrimack River below Lowell.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 14679   | 1895.<br>July 22    | Distinct.   | Cons.     | .40    | 4.05                            | 1.55                 | .0028    | .0226       | .0166      | .0060           | .30       | .0060          | .0004     | .4500            | 1.6       |
| 14680   | July 22             | Distinct.   | Cons.     | .40    | 4.65                            | 1.75                 | .0052    | .0236       | .0190      | .0046           | .32       | .0070          | .0004     | .4575            | 1.9       |
| 15248   | Sept.24             | V. slight.  | Slight.   | .25    | 3.90                            | 1.20                 | .0026    | .0240       | .0188      | .0052           | .34       | .0050          | .0002     | .3705            | 1.4       |
| 15249   | Sept.24             | Slight.     | Slight.   | .25    | 4.55                            | 1.40                 | .0062    | .0276       | .0188      | .0088           | .42       | .0120          | .0003     | .3471            | 1.6       |

Odor of the first two samples, faintly vegetable and mouldy; of the last two, distinctly vegetable. — The samples were collected from the river, a short distance below Hunt's Falls. The first and third samples were made up of several equal portions collected at different points in the north half of the river; the second and fourth were made up of several equal portions collected at different points in the south half of the river.

**MERRIMACK RIVER.***Chemical Examination of Water from the Merrimack River above Lawrence.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |           |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.   |                     |             |           |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 14692   | July 23             | Slight.     | Slight.   | .38    | 4.25                            | 1.55                 | .0092    | .0230       | .0176      | .0054           | .34       | .0040          | .0003     | .4800            | 1.6       |
| 14693   | July 23             | Slight.     | Slight.   | .52    | 4.25                            | 1.80                 | .0076    | .0210       | .0176      | .0084           | .35       | .0080          | .0003     | .4875            | 1.6       |
| 15253   | Sept. 25            | Distinct.   | Slight.   | .28    | 4.50                            | 1.50                 | .0172    | .0248       | .0190      | .0058           | .34       | .0070          | .0007     | .3962            | 1.4       |
| 15254   | Sept. 25            | Distinct.   | Slight.   | .28    | 4.45                            | 1.50                 | .0176    | .0240       | .0184      | .0056           | .35       | .0080          | .0006     | .4228            | 1.3       |

Odor, vegetable. — The samples were collected from the river, nearly opposite the intake of the Lawrence Water Works. The first and third samples were made up of several equal portions collected at different points in the north half of the river; the second and fourth were made up of several equal portions collected at different points in the south half of the river.

*Chemical Examination of Water from the Merrimack River below Lawrence.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                    |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|--------------------|--------|---------------------------------|----------------------|----------|-------------|------------|----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.          | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |                    |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended |           |                |           |                  |           |
| 1895.   |                     |             |                    |        |                                 |                      |          |             |            |                |           |                |           |                  |           |
| 14690   | July 23             | Distinct.   | Cons.,<br>fibrous. | .53    | 5.10                            | 1.90                 | .0092    | .0352       | .0220      | .0132          | .44       | .0040          | .0005     | .7050            | 2.1       |
| 14691   | July 23             | Slight.     | Cons.              | .50    | 4.65                            | 1.80                 | .0100    | .0320       | .0226      | .0094          | .42       | .0080          | .0005     | .5700            | 1.8       |
| 15255   | Sept. 25            | Distinct.   | Cons.              | .30    | 5.30                            | 1.75                 | .0126    | .0324       | .0206      | .0118          | .39       | .0080          | .0007     | .4929            | 1.6       |
| 15256   | Sept 25             | Distinct.   | Cons.              | .30    | 4.75                            | 1.50                 | .0152    | .0274       | .0210      | .0064          | .39       | .0070          | .0008     | .3884            | 1.4       |

Odor of the first and second samples, faintly vegetable and mouldy; of the third and fourth samples, distinctly vegetable. — The samples were collected from the river, about a mile below the dam at Lawrence. The first and third samples were made up of several equal portions collected at different points in the north half of the river; the second and fourth were made up of several equal portions collected at different points in the south half of the river.

## MERRIMACK RIVER.

*Chemical Examination of Water from the Merrimack River above Haverhill.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |            |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed | Hardness. |
|---------|---------------------|-------------|-----------|--------|---------------------------------|----------------------|----------|------------|------------|-----------------|-----------|----------------|-----------|-----------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid |            |                 |           | Nitrates.      | Nitrites. |                 |           |
|         |                     |             |           |        |                                 |                      |          | Total.     | Dissolved. | Sus-<br>pended. |           |                |           |                 |           |
| 1895.   |                     |             |           |        |                                 |                      |          |            |            |                 |           |                |           |                 |           |
| 14713   | July 22             | Decided.    | Cons.     | .50    | 5.35                            | 1.80                 | .0040    | .0288      | .0202      | .0086           | .42       | .0050          | .0004     | .7161           | 1.9       |
| 14712   | July 22             | Decided.    | Cons.     | .50    | 5.50                            | 1.90                 | .0042    | .0292      | .0204      | .0088           | .43       | .0050          | .0006     | .8237           | 2.1       |
| 15280   | Sept 25             | Decided.    | Cons.     | .33    | 5.85                            | 2.30                 | .0172    | .0480      | .0230      | .0250           | .49       | .0070          | .0012     | .6536           | 1.6       |
| 15261   | Sept.25             | Decided.    | Cons.     | .35    | 6.00                            | 2.35                 | .0196    | .0452      | .0270      | .0182           | .48       | .0060          | .0012     | .6084           | 1.7       |

Odor, distinctly vegetable. — The samples were collected from the river, about a mile above the Boston & Maine Railroad bridge at Haverhill, the first and third samples from the north half of the river, and the second and last from the south half.

*Chemical Examination of Water from the Merrimack River below Haverhill.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 1895.   |                     |             |           |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 14711   | July 22             | Decided.    | Cons.     | .50    | 5.20                    | 1.60              | .0094    | .0264       | .0204      | .0060      | .39       | .0070       | .0004     | .5813            | 1.8       |
| 14710   | July 22             | Decided.    | Cons.     | .50    | 5.10                    | 1.70              | .0104    | .0288       | .0190      | .0098      | .40       | .0070       | .0005     | .5920            | 1.9       |
| 15262   | Sept.25             | Decided.    | Slight.   | .35    | 5.45                    | 2.15              | .0244    | .0298       | .0232      | .0066      | .44       | .0100       | .0010     | .5008            | 1.6       |
| 15263   | Sept.25             | Distinct.   | Slight.   | .25    | 5.25                    | 1.85              | .0234    | .0264       | .0222      | .0042      | .42       | .0150       | .0010     | .4997            | 1.7       |

Odor, distinctly vegetable and unpleasant. — The samples were collected from the river, just above Hale's Island. The first and third samples were made up of several equal portions collected at different points in the north half of the river; the second and fourth were made up of several equal portions collected at different points in the south half of the river.

## NASHUA RIVER.

## NASHUA RIVER.

*Chemical Examination of Water from the North Branch of the Nashua River, below Fitchburg.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.        | Sediment.       | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                   |                 |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13875   | 1895.<br>Jan. 15    | Decided, milky.   | Cons., gray.    | 0.48   | 6.60                    | 2.30              | .0188    | .0444       | .0290      | .0154      | 0.69      | .0270       | .0002     | 0.7505           | 2.1       |
| 13849   | Feb. 19             | Distinct          | Cons., gray.    | 0.45   | 8.60                    | 2.60              | .0672    | .0422       | .0354      | .0068      | 0.86      | .0150       | .0007     | 0.6201           | 2.1       |
| 14025   | Mar. 20             | Distinct, milky.  | Cons., gray.    | 0.43   | 6.25                    | 1.85              | .0160    | .0258       | .0196      | .0062      | 0.53      | .0180       | .0004     | 0.6162           | 1.9       |
| 14151   | Apr. 16             | Distinct, clayey. | Slight.         | 0.50   | 3.40                    | 1.70              | .0034    | .0178       | .0152      | .0026      | 0.28      | .0180       | .0002     | 0.5767           | 1.3       |
| 14314   | May 16              | Distinct, milky.  | Cons., dirty.   | 0.53   | 7.10                    | 3.10              | .0150    | .0334       | .0234      | .0100      | 0.44      | .0050       | .0003     | 0.6478           | 1.7       |
| 14489   | June 18             | Decided.          | Cons., brown.   | 0.70   | 10.70                   | 2.60              | .4992    | .0582       | .0446      | .0136      | 1.21      | .0100       | .0016     | 0.6591           | 2.7       |
| 14667   | July 22             | Distinct.         | Cons., gray.    | 0.75   | 11.90                   | 2.50              | .1800    | .0560       | .0410      | .0150      | 1.46      | .0050       | .0014     | 0.8325           | 3.5       |
| 14875   | Aug. 20             | Decided, milky.   | Cons., brown.   | 0.48   | 9.20                    | 3.15              | .0656    | .0368       | .0284      | .0084      | 1.40      | .0080       | .0029     | 0.6162           | 3.0       |
| 15192   | Sept. 16            | Distinct, milky.  | Cons., dirty.   | 0.65   | 12.05                   | 3.25              | .0560    | .0534       | .0472      | .0062      | 1.30      | .0030       | .0019     | 0.7527           | 3.4       |
| 15394   | Oct. 17             | Decided.          | Cons., fibrous. | 1.00   | 7.00                    | 3.05              | .0148    | .0536       | .0376      | .0160      | 0.71      | .0100       | .0006     | 1.1716           | 1.9       |
| 15575   | Nov. 19             | Decided.          | Cons.           | 0.70   | 5.10                    | 1.75              | .0164    | .0380       | .0300      | .0080      | 0.38      | .0170       | .0003     | 0.8736           | 1.3       |
| 15762   | Dec. 17             | Decided, milky.   | Cons.           | 0.40   | 8.65                    | 3.10              | .0456    | .0480       | .0320      | .0160      | 0.72      | .0250       | .0012     | 0.7161           | 1.9       |
| Av.     | .....               | .....             | .....           | 0.59   | 8.10                    | 2.58              | .0832    | .0423       | .0319      | .0104      | 0.75      | .0134       | .0010     | 0.7361           | 2.2       |

## Averages by Years.

|   |      |   |   |      |      |      |       |       |       |       |      |       |       |        |     |
|---|------|---|---|------|------|------|-------|-------|-------|-------|------|-------|-------|--------|-----|
| - | 1893 | - | - | 0.57 | 7.46 | 2.16 | .0461 | .0360 | .0257 | .0103 | 0.69 | .0118 | .0018 | 0.6927 | 2.0 |
| - | 1894 | - | - | 0.56 | 7.39 | 2.00 | .0634 | .0346 | .0251 | .0095 | 0.75 | .0152 | .0020 | 0.5922 | 1.9 |
| - | 1895 | - | - | 0.59 | 8.10 | 2.58 | .0832 | .0423 | .0319 | .0104 | 0.75 | .0134 | .0010 | 0.7361 | 2.2 |

NOTE to analyses of 1895: Odor, generally musty and disagreeable, sometimes offensive. — The samples were collected from the river about half a mile below the point where water from the tail-race of the Falulah Paper Company enters the stream.

## NASHUA RIVER.

*Chemical Examination of Water from the North Branch of the Nashua River, just above its Confluence with the South Branch at Lancaster.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.          |                    |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|----------------------|--------------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.           | Sediment.          | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                      |                    |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 13670   | 1895.<br>Jan. 15    | Decided,<br>milky.   | Cons.,<br>earthy.  | .50    | 5.70                            | 1.95                 | .0244    | .0264       | .0232      | .0032           | 0.56      | .0220          | .0002     | .6241            | 1.7       |
| 13846   | Feb. 19             | Distinct.            | Cons.              | .50    | 7.60                            | 2.10                 | .0432    | .0312       | .0214      | .0098           | 0.86      | .0180          | .0003     | .6513            | 1.8       |
| 14002   | Mar. 19             | Decided.             | Heavy,<br>gray.    | .42    | 4.60                            | 1.35                 | .0198    | .0294       | .0206      | .0088           | 0.41      | .0250          | .0003     | .6130            | 1.4       |
| 14156   | Apr. 16             | Distinct,<br>clayey. | Cons.              | .53    | 3.70                            | 1.80                 | .0034    | .0176       | .0150      | .0026           | 0.29      | .0180          | .0002     | .6257            | 1.1       |
| 14339   | May 21              | Decided.             | Cons.,<br>gray.    | .60    | 5.80                            | 1.65                 | .0250    | .0190       | .0170      | .0020           | 0.54      | .0100          | .0005     | .6122            | 1.6       |
| 14517   | June 20             | Distinct,<br>milky.  | Cons.,<br>brown.   | .55    | 7.70                            | 2.60                 | .0880    | .0380       | .0220      | .0160           | 0.97      | .0200          | .0055     | .5159            | 2.2       |
| 14702   | July 24             | Distinct.            | Cons.              | .67    | 8.60                            | 2.00                 | .0232    | .0240       | .0200      | .0040           | 1.12      | .0270          | .0060     | .5467            | 2.6       |
| 14825   | Aug. 13             | Slight.              | Slight.            | .35    | 9.30                            | 2.20                 | .0136    | .0244       | .0232      | .0012           | 1.20      | .0300          | .0042     | .5616            | 3.0       |
| 14910   | Aug. 26             | Slight.              | Slight.            | .40    | 9.20                            | 2.30                 | .0100    | .0232       | .0188      | .0044           | 1.06      | .0350          | .0025     | .4992            | 2.2       |
| 15109   | Sept. 9             | Slight.              | Slight,<br>brown.  | .32    | 8.25                            | 1.95                 | .0124    | .0238       | .0214      | .0024           | 1.22      | .0550          | .0068     | .4836            | 2.2       |
| 15234   | Sept. 23            | V. slight.           | Slight.            | .30    | 9.45                            | 2.05                 | .0044    | .0194       | .0174      | .0020           | 1.36      | .0430          | .0014     | .4329            | 2.6       |
| 15326   | Oct. 8              | V. slight.           | V. slight.         | .30    | 9.80                            | 2.80                 | .0400    | .0220       | .0196      | .0024           | 1.33      | .0330          | .0016     | .4914            | 2.7       |
| 15410   | Oct. 23             | Distinct.            | Cons.,<br>grayish. | .75    | 8.40                            | 2.95                 | .0392    | .0344       | .0304      | .0040           | 0.90      | .0180          | .0007     | .8814            | 2.1       |
| 15508   | Nov. 11             | Distinct,<br>milky.  | Slight,<br>brown.  | .68    | 7.30                            | 2.20                 | .0314    | .0370       | .0294      | .0076           | 0.65      | .0180          | .0006     | .6848            | 1.9       |
| 15608   | Nov. 25             | Decided.             | Cons.              | .58    | 5.05                            | 1.85                 | .0080    | .0188       | .0132      | .0056           | 0.37      | .0150          | .0003     | .6123            | 1.6       |
| 15750   | Dec. 17             | Decided.             | Cons.,<br>fibrous. | .48    | 6.45                            | 2.25                 | .0318    | .0352       | .0238      | .0114           | 0.54      | .0200          | .0008     | .6237            | 1.7       |
| Av.*    | .....               | .....                | .....              | .51    | 6.96                            | 2.10                 | .0282    | .0269       | .0208      | .0061           | 0.77      | .0236          | .0019     | .5947            | 1.9       |

## Averages by Years.

|   |       |   |   |     |       |      |       |       |       |       |      |       |       |       |     |
|---|-------|---|---|-----|-------|------|-------|-------|-------|-------|------|-------|-------|-------|-----|
| - | 1888† | - | - | .56 | 7.47  | 1.82 | .0118 | .0287 | .0261 | .0026 | 0.72 | .0257 | .0012 | -     | -   |
| - | 1890† | - | - | .38 | 6.77  | 2.12 | .0117 | .0326 | .0274 | .0052 | 0.62 | .0214 | .0014 | -     | 2.6 |
| - | 1891‡ | - | - | .46 | 10.20 | 2.25 | .0365 | .0266 | .0235 | .0031 | 1.18 | .0331 | .0012 | -     | 2.8 |
| - | 1892  | - | - | .48 | 9.75  | 2.10 | .0422 | .0274 | .0237 | .0037 | 1.11 | .0450 | .0010 | -     | 3.0 |
| - | 1894¶ | - | - | .51 | 8.13  | 1.98 | .0312 | .0245 | .0199 | .0046 | 0.98 | .0287 | .0010 | .4955 | 2.3 |
| - | 1895  | - | - | .51 | 6.96  | 2.10 | .0282 | .0269 | .0208 | .0061 | 0.77 | .0236 | .0019 | .5947 | 1.9 |

\* Where more than one sample was collected in a month the average analysis for that month has been used in making the average.

† Four samples on September 17.

‡ Five samples in July and August.

§ August and October.

|| August, October and November.

¶ July to December.

NOTE to analyses of 1895: Odor, generally musty and sometimes disagreeable; in September, vegetable. — The samples were collected from the river at the railroad bridge, a short distance above its mouth.



## NASHUA RIVER.

*Chemical Examination of Water from the Quinepoxet River in Holden.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |                |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                 | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|------------------|----------------|--------|---------------------------------|----------------------|----------|-------------|------------|-----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.       | Sediment.      | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                 |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |                  |                |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended. |           |                |           |                  |           |
| 1895.   |                     |                  |                |        |                                 |                      |          |             |            |                 |           |                |           |                  |           |
| 13593   | Jan. 2              | Distinct, milky. | Slight.        | 0.67   | 5.55                            | 2.10                 | .0028    | .0262       | .0238      | .0024           | .38       | .0180          | .0001     | 0.7099           | 1.4       |
| 13755   | Feb. 4              | Distinct.        | Cons., gray.   | 0.75   | 5.90                            | 2.20                 | .0026    | .0384       | .0338      | .0046           | .40       | .0180          | .0000     | 0.9164           | 1.4       |
| 13929   | Mar. 5              | Slight.          | Cons., earthy. | 0.55   | 4.30                            | 1.45                 | .0032    | .0280       | .0202      | .0078           | .25       | .0100          | .0000     | 0.6129           | 0.9       |
| 14077   | Apr. 1              | Slight.          | Slight.        | 0.60   | 3.45                            | 1.50                 | .0004    | .0238       | .0206      | .0032           | .17       | .0030          | .0000     | 0.5914           | 0.5       |
| 14235   | May 1               | Slight.          | Cons.          | 0.68   | 3.05                            | 1.70                 | .0000    | .0194       | .0172      | .0022           | .18       | .0020          | .0001     | 0.6468           | 0.5       |
| 14418   | June 4              | Distinct.        | Cons.          | 0.90   | 4.20                            | 1.95                 | .0014    | .0360       | .0218      | .0142           | .24       | .0060          | .0000     | 0.8284           | 0.8       |
| 14578   | July 2              | Distinct.        | Slight.        | 1.20   | 3.95                            | 1.75                 | .0030    | .0358       | .0282      | .0076           | .19       | .0050          | .0000     | 0.9230           | 0.8       |
| 14776   | Aug. 5              | Distinct.        | Slight.        | 0.80   | 5.50                            | 2.90                 | .0012    | .0290       | .0264      | .0026           | .22       | .0160          | .0001     | 0.8190           | 1.4       |
| 14966   | Sept. 3             | Slight.          | Slight.        | 0.60   | 4.50                            | 2.10                 | .0004    | .0254       | .0198      | .0056           | .29       | .0050          | .0000     | 0.5991           | 0.5       |
| 15307   | Oct. 2              | Distinct.        | Slight.        | 0.48   | 4.90                            | 1.90                 | .0000    | .0304       | .0282      | .0022           | .34       | .0070          | .0000     | 0.5772           | 0.6       |
| 15455   | Nov. 2              | Slight.          | Slight.        | 1.10   | 4.50                            | 2.30                 | .0002    | .0324       | .0282      | .0042           | .28       | .0150          | .0000     | 1.1872           | 0.9       |
| 15669   | Dec. 3              | V. slight.       | Slight.        | 0.93   | 3.90                            | 1.80                 | .0000    | .0222       | .0192      | .0030           | .17       | .0030          | .0000     | 0.8424           | 0.6       |
| Av.     | .....               | .....            | .....          | 0.77   | 4.47                            | 1.97                 | .0020    | .0289       | .0239      | .0050           | .26       | .0090          | .0003     | 0.7770           | 0.9       |

*Averages by Years.*

|   |       |   |   |      |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|------|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1892  | - | - | 0.62 | 3.70 | 1.49 | .0014 | .0104 | .0158 | .0036 | .19 | .0088 | .0001 | -     | 0.9 |
| - | 1893* | - | - | 0.72 | 3.75 | 1.57 | .0004 | .0192 | .0160 | .0032 | .26 | .0044 | .0001 | .6477 | 0.9 |
| - | 1894  | - | - | 0.61 | 3.85 | 1.47 | .0041 | .0214 | .0171 | .0043 | .29 | .0027 | .0001 | .5830 | 0.7 |
| - | 1895  | - | - | 0.77 | 4.47 | 1.97 | .0020 | .0289 | .0239 | .0050 | .26 | .0090 | .0003 | .7770 | 0.9 |

\* August to December.

NOTE to analyses of 1895: Odor, vegetable. — The samples were collected from the river at Smith's Woollen Mill in Holden, and 1,000 feet from the line between Holden and West Boylston.

## NASHUA RIVER.

## Chemical Examination of Water from the Stillwater River in Sterling.

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.   |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|---------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.    | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |               |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13594   | 1895.<br>Jan. 2     | None.         | V. slight. | .40    | 3.75                    | 1.30              | .0002    | .0118       | .0104      | .0014      | .20       | .0070       | .0000     | .4697            | 1.1       |
| 13754   | Feb. 4              | V. slight.    | V. slight. | .50    | 3.35                    | 0.95              | .0022    | .0130       | .0122      | .0008      | .20       | .0030       | .0000     | .5372            | 0.6       |
| 13928   | Mar. 5              | V. slight.    | Slight.    | .30    | 3.35                    | 1.40              | .0008    | .0116       | .0102      | .0014      | .18       | .0100       | .0000     | .4897            | 0.9       |
| 14076   | Apr. 1              | V. slight.    | Cons.      | .50    | 2.65                    | 0.80              | .0002    | .0134       | .0118      | .0016      | .14       | .0030       | .0000     | .4851            | 0.3       |
| 14234   | May 1               | V. slight.    | Slight.    | .60    | 2.80                    | 1.45              | .0000    | .0178       | .0152      | .0026      | .16       | .0030       | .0000     | .5582            | 0.8       |
| 14419   | June 4              | Slight.       | Cons.      | .60    | 3.35                    | 1.40              | .0008    | .0204       | .0176      | .0028      | .17       | .0050       | .0000     | .6080            | 0.8       |
| 14577   | July 2              | Slight.       | Slight.    | .80    | 3.85                    | 1.75              | .0006    | .0228       | .0200      | .0028      | .14       | .0030       | .0000     | .8271            | 0.9       |
| 14775   | Aug. 5              | Slight.       | Slight.    | .37    | 3.50                    | 1.25              | .0026    | .0212       | .0200      | .0012      | .18       | .0150       | .0001     | .5070            | 1.8       |
| 14967   | Sept. 3             | Slight.       | Slight.    | .30    | 3.80                    | 1.75              | .0012    | .0184       | .0168      | .0016      | .18       | .0000       | .0000     | .4119            | 0.8       |
| 15306   | Oct. 2              | Slight.       | Slight.    | .30    | 3.65                    | 1.60              | .0008    | .0214       | .0202      | .0012      | .27       | .0030       | .0000     | .3838            | 0.8       |
| 15454   | Nov. 2              | Sl't., flocc. | Slight.    | .90    | 4.30                    | 2.20              | .0000    | .0254       | .0238      | .0016      | .28       | .0070       | .0001     | .9828            | 0.9       |
| 15670   | Dec. 3              | None.         | V. slight. | .68    | 3.45                    | 1.55              | .0000    | .0172       | .0150      | .0022      | .17       | .0020       | .0000     | .6770            | 0.6       |
| Av.     | .....               | .....         | .....      | .52    | 3.48                    | 1.45              | .0008    | .0179       | .0161      | .0018      | .19       | .0051       | .0000     | .5781            | 0.9       |

## Averages by Years.

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1892  | - | - | .44 | 3.38 | 1.18 | .0001 | .0131 | .0109 | .0022 | .13 | .0072 | .0000 | -     | 0.9 |
| - | 1893* | - | - | .50 | 3.45 | 1.38 | .0006 | .0147 | .0126 | .0021 | .18 | .0022 | .0001 | .4931 | 0.7 |
| - | 1894  | - | - | .45 | 3.20 | 1.14 | .0008 | .0137 | .0115 | .0022 | .18 | .0017 | .0000 | .4442 | 0.8 |
| - | 1895  | - | - | .52 | 3.48 | 1.45 | .0008 | .0179 | .0161 | .0018 | .19 | .0051 | .0000 | .5781 | 0.9 |

\* August to December.

NOTE to analyses of 1895: Odor, vegetable. — The samples were collected from the river at a highway bridge about 1 mile above the line between Sterling and West Boylston.

## NASHUA RIVER.

*Chemical Examination of Water from the South Branch of the Nashua River above Clinton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS. |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|--------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.    | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |              |           |                  |           |
| 13596   | 1895.<br>Jan. 2     | Slight.     | Slight.   | .48    | 4.95                    | 1.85              | .0002    | .0230       | .0212      | .0018      | .34       | .0150        | .0600     | .5062            | 1.6       |
| 13752   | Feb. 4              | V. slight.  | Slight.   | .40    | 4.45                    | 1.80              | .0016    | .0332       | .0282      | .0050      | .32       | .0180        | .0000     | .5490            | 1.3       |
| 13919   | Mar. 4              | Slight.     | Slight.   | .30    | 3.95                    | 1.25              | .0036    | .0200       | .0130      | .0070      | .29       | .0150        | .0000     | .4581            | 1.4       |
| 14080   | Apr. 1              | Slight.     | Slight.   | .48    | 3.15                    | 1.20              | .0014    | .0176       | .0146      | .0030      | .18       | .0090        | .0001     | .4851            | 0.9       |
| 14233   | May 1               | Slight.     | Cons.     | .50    | 3.10                    | 1.35              | .0004    | .0190       | .0162      | .0028      | .22       | .0050        | .0001     | .5120            | 0.8       |
| 14410   | June 3              | Slight.     | Slight.   | .55    | 3.60                    | 0.95              | .0030    | .0192       | .0142      | .0050      | .21       | .0050        | .0000     | .5662            | 0.9       |
| 14563   | June 29             | Slight.     | Cons.     | .30    | 4.15                    | 1.20              | .0000    | .0260       | .0220      | .0040      | .28       | .0030        | .0002     | .4440            | 1.3       |
| 14707   | Aug. 5              | Slight.     | Slight.   | .35    | 4.00                    | 1.45              | .0016    | .0192       | .0162      | .0030      | .24       | .0150        | .0001     | .5382            | 1.6       |
| 14948   | Sept. 1             | Slight.     | Slight.   | .30    | 4.20                    | 1.45              | .0006    | .0206       | .0156      | .0050      | .27       | .0050        | .0000     | .3927            | 1.9       |
| 15292   | Oct. 1              | Slight.     | Slight.   | .25    | 4.00                    | 1.15              | .0004    | .0212       | .0176      | .0036      | .30       | .0030        | .0000     | .2746            | 1.4       |
| 15471   | Nov. 4              | Slight.     | Slight.   | .90    | 4.65                    | 1.95              | .0000    | .0252       | .0230      | .0022      | .29       | .0100        | .0002     | .8908            | 1.1       |
| 15657   | Dec. 2              | Slight.     | Slight.   | .70    | 3.85                    | 1.70              | .0018    | .0264       | .0246      | .0018      | .19       | .0050        | .0000     | .7862            | 0.9       |
| Av.     | .....               | .....       | .....     | .46    | 4.00                    | 1.44              | .0017    | .0226       | .0189      | .0037      | .26       | .0090        | .0001     | .5338            | 1.3       |

## Averages by Years.

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |       |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|-------|-----|
| - | 1887* | - | - | .58 | 4.14 | 1.24 | .0015 | .0216 | -     | -     | .21 | .0077 | -     | -     | -   |
| - | 1888  | - | - | .32 | 3.53 | 1.06 | .0008 | .0151 | -     | -     | .18 | .0097 | .0001 | -     | -   |
| - | 1889† | - | - | .24 | 2.96 | 0.87 | .0004 | .0163 | .0133 | .0030 | .18 | .0062 | .0002 | -     | -   |
| - | 1893‡ | - | - | .41 | 3.99 | 1.42 | .0006 | .0158 | .0129 | .0029 | .28 | .0020 | .0001 | .4623 | 1.4 |
| - | 1894  | - | - | .44 | 3.81 | 1.27 | .0014 | .0154 | .0123 | .0031 | .25 | .0042 | .0000 | .4174 | 1.1 |
| - | 1895  | - | - | .46 | 4.00 | 1.44 | .0017 | .0226 | .0189 | .0037 | .26 | .0090 | .0000 | .5338 | 1.3 |

\* June to December.

† January to May.

‡ August to December.

NOTE to analyses of 1895: Odor, vegetable, and frequently mouldy. — The samples were collected from the river above the dam of the Lancaster Manufacturing Company.

## NASHUA RIVER.

*Chemical Examination of Water from the South Branch of the Nashua River, just above its Confluence with the North Branch at Lancaster.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.       |                      |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------------|----------------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.        | Sediment.            | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |                   |                      |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13069   | 1895.<br>Jan. 15    | Distinct, milky.  | Cons., dirty.        | .60    | 5.25                    | 1.95              | .0196    | .0300       | .0228      | .0072      | .36       | .0120       | .0002     | 0.7268           | 1.1       |
| 13845   | Feb. 19             | Distinct.         | Cons.                | .55    | 5.10                    | 1.90              | .0152    | .0204       | .0158      | .0046      | .43       | .0150       | .0001     | 0.6006           | 1.6       |
| 14001   | Mar. 19             | Distinct.         | Cons., dark.         | .52    | 4.00                    | 1.55              | .0078    | .0210       | .0176      | .0034      | .23       | .0180       | .0002     | 0.6146           | 1.4       |
| 14155   | Apr. 16             | Distinct, clayey. | Cons.                | .60    | 3.40                    | 1.45              | .0048    | .0184       | .0152      | .0032      | .23       | .0080       | .0001     | 0.6715           | 1.0       |
| 14338   | May 21              | Decided.          | Cons., gray.         | .50    | 4.50                    | 1.45              | .0136    | .0252       | .0192      | .0060      | .30       | .0070       | .0002     | 0.6241           | 1.3       |
| 14516   | June 20             | Distinct, milky.  | Slight, dark.        | .50    | 4.95                    | 2.15              | .0368    | .0260       | .0216      | .0044      | .38       | .0050       | .0006     | 0.5082           | 1.3       |
| 14701   | July 24             | Distinct.         | Cons.                | .50    | 3.90                    | 1.40              | .0114    | .0120       | .0098      | .0022      | .34       | .0050       | .0003     | 0.5082           | 1.6       |
| 14826   | Aug. 13             | Slight.           | Slight.              | .35    | 4.75                    | 1.80              | .0184    | .0272       | .0224      | .0048      | .33       | .0110       | .0013     | 0.5226           | 1.8       |
| 14909   | Aug. 26             | Distinct.         | Cons., brown.        | .35    | 5.15                    | 1.90              | .0116    | .0140       | .0108      | .0032      | .38       | .0150       | .0030     | 0.4953           | 1.1       |
| 15110   | Sept. 9             | Distinct, milky.  | Cons., brown.        | .30    | 5.45                    | 1.10              | .0496    | .0264       | .0236      | .0028      | .41       | .0100       | .0025     | 0.4836           | 1.9       |
| 15233   | Sept. 23            | Slight.           | Cons., brown, flocc. | .40    | 5.80                    | 2.00              | .0540    | .0310       | .0250      | .0060      | .52       | .0150       | .0050     | 0.4196           | 1.7       |
| 15325   | Oct. 8              | V. slight, milky. | V. slight.           | .28    | 5.25                    | 1.65              | .0260    | .0320       | .0242      | .0078      | .56       | .0100       | .0027     | 0.3962           | 1.8       |
| 15409   | Oct. 23             | Slight.           | Cons.                | .97    | 5.70                    | 2.85              | .0084    | .0284       | .0268      | .0016      | .44       | .0120       | .0003     | 1.0748           | 1.6       |
| 15507   | Nov. 11             | Distinct.         | Slight, brown.       | .70    | 4.65                    | 1.75              | .0092    | .0228       | .0190      | .0038      | .30       | .0130       | .0002     | 0.7683           | 1.6       |
| 15607   | Nov. 25             | Distinct.         | Slight.              | .87    | 4.30                    | 2.05              | .0016    | .0432       | .0144      | .0288      | .21       | .0080       | .0002     | 0.9126           | 0.9       |
| 15751   | Dec. 17             | Slight.           | Cons.                | .48    | 4.35                    | 1.85              | .0038    | .0198       | .0168      | .0030      | .20       | .0200       | .0001     | 0.5852           | 1.3       |
| Av.*    | .....               | .....             | .....                | .53    | 4.66                    | 1.77              | .0167    | .0238       | .0185      | .0053      | .34       | .0114       | .0008     | 0.6146           | 1.4       |

## Averages by Years.

|   |       |   |   |     |      |      |       |       |       |       |     |       |       |        |     |
|---|-------|---|---|-----|------|------|-------|-------|-------|-------|-----|-------|-------|--------|-----|
| - | 1888† | - | - | .20 | 4.91 | 1.11 | .0264 | .0230 | .0173 | .0047 | .38 | .0192 | .0008 | -      | -   |
| - | 1890† | - | - | .30 | 4.68 | 1.85 | .0162 | .0288 | .0213 | .0075 | .31 | .0104 | .0003 | -      | 1.7 |
| - | 1891‡ | - | - | .45 | 6.01 | 2.22 | .0141 | .0338 | .0242 | .0096 | .39 | .0093 | .0003 | -      | 1.6 |
| - | 1892  | - | - | .43 | 5.68 | 1.65 | .0181 | .0267 | .0214 | .0053 | .59 | .0150 | .0006 | -      | 1.8 |
| - | 1894¶ | - | - | .52 | 6.31 | 1.91 | .0532 | .0285 | .0226 | .0076 | .57 | .0095 | .0017 | 0.4758 | 1.8 |
| - | 1895  | - | - | .53 | 4.66 | 1.77 | .0167 | .0238 | .0185 | .0053 | .34 | .0114 | .0008 | 0.6146 | 1.4 |

\* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

† Four samples on September 17.

‡ Four samples in July and August.

§ August and October.

|| August, October and November.

¶ July to December.

NOTE to analyses of 1895 Odor, generally musty and sometimes disagreeable; from July to September, generally vegetable. — The samples were collected from the river at the Atherton bridge, a short distance above its mouth.

## NEPONSET RIVER.

## NEPONSET RIVER.

An investigation of the condition of the Neponset River was made in August and September, 1895, and the results of the examination of samples of water from many points on the main river and its tributaries are given below. A similar investigation was made in 1891,

*Chemical Examination of Water*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |            |            | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |                 |       |
|---------|---------------------|---------------------|------------|------------|-------------------------|-------------------|----------|-------------|------------|-----------------|-------|
|         |                     | Turbidity.          | Sediment.  | Color.     | Total.                  | Loss on Ignition. | Free.    | ALBUMINOID. |            |                 |       |
|         |                     |                     |            |            |                         |                   |          | Total.      | Dissolved. | Sus-<br>pended. |       |
| 1895.   |                     |                     |            |            |                         |                   |          |             |            |                 |       |
| 1       | *16381              | Aug. 23, 12.10 P.M. | V. slight. | V. slight. | 0.90                    | 7.30              | 3.50     | 0.0008      | 0.0236     | .0232           | .0004 |
| 2       | 16382               | Aug. 23, 12.35 P.M. | V. slight. | Slight.    | 1.18                    | 8.50              | 3.00     | 0.0010      | 0.0398     | .0310           | .0088 |
| 3       | 16383               | Aug. 23, 1.30 P.M.  | V. slight. | Slight.    | 1.01                    | 7.80              | 2.50     | 0.0012      | 0.0352     | .0290           | .0062 |
| 4       | 16384               | Aug. 23, 1.50 P.M.  | Decided.   | Decided.   | 0.65                    | 32.20             | 10.30    | 0.0080      | 0.0780     | .0440           | .0340 |
| 5       | 16385               | Aug. 23, 2.05 P.M.  | Decided.   | Decided.   | 0.89                    | 28.80             | 8.90     | 0.0040      | 0.0660     | .0420           | .0240 |
| 6       | 16386               | Aug. 23, 2.20 P.M.  | Decided.   | Heavy.     | 1.12                    | 191.40            | 99.00    | 0.0100      | 0.4200     | .0460           | .3740 |
| 7       | 16387               | Aug. 23, 3.45 P.M.  | Decided.   | Decided.   | 0.95                    | 35.50             | 12.10    | 0.0060      | 0.0660     | .0540           | .0120 |
| 8       | 16388               | Aug. 23, 4.00 P.M.  | Decided.   | Decided.   | 0.97                    | 34.40             | 11.70    | 0.0060      | 0.0660     | .0460           | .0100 |
| 9       | 16389               | Aug. 23, 4.15 P.M.  | Decided.   | Heavy.     | 1.85                    | 83.50             | 27.20    | 1.2000      | 0.7800     | .5300           | .2500 |
| 10      | 16390               | Aug. 23, 4.30 P.M.  | Decided.   | Heavy.     | 0.93                    | 52.20             | 12.30    | 0.3100      | 0.2640     | .1460           | .1180 |
| 11      | 16391               | Aug. 23, 4.45 P.M.  | Decided.   | Decided.   | 0.90                    | 39.60             | 8.10     | 0.1680      | 0.2100     | .1640           | .0460 |
| 12      | 16392               | Aug. 23, 5.20 P.M.  | Decided.   | Decided.   | 0.94                    | 35.50             | 8.90     | 0.0800      | 0.1360     | .0960           | .0400 |
| 13      | 16393               | Aug. 23, 5.30 P.M.  | Decided.   | Heavy.     | 1.90                    | 544.00            | 121.00   | 3.0000      | 1.2400     | .8700           | .3700 |
| 14      | 16394               | Aug. 23, 5.10 P.M.  | Decided.   | Decided.   | 0.93                    | 40.30             | 12.10    | 0.0840      | 0.1480     | .1140           | .0340 |
| 15      | 16426               | Aug. 29, 11.50 A.M. | Decided.   | Heavy.     | 1.02                    | 46.07             | 11.17    | 0.1480      | 0.2120     | .0720           | .1400 |
| 16      | 16427               | Aug. 29, 12.30 P.M. | Decided.   | Decided.   | 1.00                    | 35.40             | 9.50     | 0.1220      | 0.1560     | .1040           | .0520 |
| 17      | 16428               | Aug. 29, 12.40 P.M. | Slight.    | Decided.   | 0.98                    | 10.30             | 4.30     | 0.0040      | 0.0360     | .0220           | .0140 |
| 18      | 16429               | Aug. 29, 12.50 P.M. | Slight.    | Decided.   | 0.90                    | 11.20             | 4.70     | 0.0060      | 0.0560     | .0340           | .0220 |
| 19      | 16430               | Aug. 29, 2.30 P.M.  | Slight.    | Slight.    | 1.01                    | 14.20             | 5.10     | 0.0554      | 0.0648     | .0508           | .0140 |
| 20      | 16431               | Aug. 29, 3.35 P.M.  | Slight.    | Slight.    | 0.91                    | 13.50             | 4.50     | 0.0560      | 0.0608     | .0460           | .0148 |
| 21      | 16432               | Aug. 29, 4.30 P.M.  | V. slight. | Slight.    | 0.62                    | 14.10             | 4.60     | 0.0654      | 0.0492     | .0382           | .0110 |
| 22      | 16433               | Aug. 29, 5.25 P.M.  | V. slight. | Decided.   | 0.65                    | 15.50             | 6.90     | 0.0994      | 0.0480     | .0394           | .0066 |
| 23      | 16434               | Aug. 29, 5.35 P.M.  | V. slight. | Decided.   | 0.62                    | 8.40              | 2.70     | 0.0026      | 0.0344     | .0244           | .0100 |
| 24      | 16435               | Aug. 29, 5.45 P.M.  | Slight.    | Decided.   | 0.63                    | 11.80             | 5.10     | 0.0298      | 0.0492     | .0374           | .0115 |
| 25      | 16482               | Sept. 5, 11.20 A.M. | V. slight. | Slight.    | 0.60                    | 12.00             | 4.00     | 0.0640      | 0.0486     | .0366           | .0130 |
| 26      | 16483               | Sept. 5, 11.55 A.M. | V. slight. | Slight.    | 0.59                    | 10.85             | 5.35     | 0.0892      | 0.0466     | .0406           | .0060 |
| 27      | 16484               | Sept. 5, 12.30 P.M. | Slight.    | Decided.   | 0.60                    | -                 | -        | 0.0916      | 0.0514     | .0386           | .0128 |
| 28      | 16485               | Sept. 5, 1.30 P.M.  | Slight.    | Decided.   | 0.62                    | 20.80             | 7.05     | 0.0788      | 0.0540     | .0436           | .0104 |
| 29      | 16486               | Sept. 5, 2.00 P.M.  | V. slight. | Slight.    | 0.60                    | -                 | -        | 0.0526      | 0.0434     | .0342           | .0092 |
| 30      | 16487               | Sept. 5, 2.30 P.M.  | V. slight. | V. slight. | 0.40                    | -                 | -        | 0.0492      | 0.0404     | .0288           | .0116 |

\* These analyses were made at the Lawrence Experiment Station.

The samples were collected as follows: No. 16381, from the Neponset River where Main Street crosses it, just above the village of Walpole; No. 16382, at Stetson's dam, just below the village of Walpole; No. 16383, from the mill-pond of the paper-mill of F. W. Bird & Son, in East Walpole; No. 16384, at the Washington Street bridge in East Walpole, just below the paper-mill of F. W. Bird & Son; No. 16385, at the dam of the paper-mill of Hollingsworth & Vose, which is the next below the paper-mill of F. W. Bird & Son; No. 16386, about 100 feet below the paper-mill of Hollingsworth & Vose; No. 16387, at the next dam below the mill of Hollingsworth & Vose, at Water Street; No. 16388, at the Moore Street bridge in Norwood, about 100 feet above the brook which conveys the drainage from Winslow's Tannery to the river; No. 16389, from the brook which conveys the drainage from Winslow's Tannery to the Neponset River, about 100 feet above its junction with the river; No. 16390, from the Neponset River, about 100 feet below the brook from Winslow's Tannery; No. 16391, at the dam of the Printing-Ink Works of Geo. H. Morrill & Co., Pleasant Street, Norwood; No. 16392, from the Neponset

## NEPONSET RIVER.

the results of which were given on pages 319-336 of the annual report for that year.

Both examinations were made at a time of low flow in the river, and a comparison of the analyses indicates that the condition of the river was generally worse in 1895 than at the time when the examination was made in 1891.

*from the Neponset River.*

[Parts per 100,000.]

| Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. | Locality.                                                  |    |
|-----------|-------------|-----------|------------------|--------------------------------|------------------------------------------------------------|----|
|           | Nitrates.   | Nitrites. |                  |                                |                                                            |    |
| 0.45      | .0010       | .0000     | 0.76             | 71                             | Above Walpole.                                             | 1  |
| 0.78      | .0000       | .0000     | 1.11             | 37,500                         | Above Stetson's Dam.                                       | 2  |
| 0.60      | .0010       | .0000     | 0.98             | 900                            | Above paper-mill of F. W. Bird & Son.                      | 3  |
| 2.18      | .0010       | .0000     | 2.68             | 57,400                         | Below paper-mill of F. W. Bird & Son.                      | 4  |
| 1.81      | .0000       | .0000     | 8.00             | 235,000                        | Above paper-mill of Hollingsworth & Vose.                  | 5  |
| 4.37      | .0015       | .0000     | 18.60            | 63,000                         | Below paper-mill of Hollingsworth & Vose.                  | 6  |
| 3.03      | .0000       | .0000     | 3.60             | 470,000                        | Next dam below paper-mill of Hollingsworth & Vose.         | 7  |
| 2.81      | .0020       | .0000     | 3.20             | Lost.                          | Above brook from Winslow's tannery.                        | 8  |
| 17.16     | .0100       | .0006     | 5.70             | 335,000                        | Brook from Winslow's tannery.                              | 9  |
| 7.25      | .0050       | .0000     | 4.00             | 385,000                        | Below brook from Winslow's tannery.                        | 10 |
| 6.88      | .0050       | .0000     | 2.80             | 660,000                        | Above ink works.                                           | 11 |
| 5.69      | .0030       | .0000     | 2.40             | 600,000                        | Below ink works.                                           | 12 |
| 174.50    | .0010       | .0000     | 56.40            | 3,950,000                      | Sewer from Smith's tannery.                                | 13 |
| 7.71      | .0030       | .0000     | 3.00             | 515,000                        | Below sewer from Smith's tannery and near head of meadows. | 14 |
| 8.32      | .0030       | .0000     | 5.10             | 295,000                        | Below sewer from Smith's tannery and near head of meadows. | 15 |
| 7.31      | .0020       | .0000     | 2.60             | 571,000                        | Above Canton River.                                        | 16 |
| 0.68      | .0000       | .0000     | 1.14             | 9,000                          | Canton River, near Main River.                             | 17 |
| 1.35      | .0020       | .0000     | 1.26             | 171,000                        | Below Canton River.                                        | 18 |
| 1.67      | .0010       | .0000     | 1.28             | 33,000                         | Bridge at Dedham Road.                                     | 19 |
| 1.69      | .0010       | .0010     | 1.18             | 36,000                         | Bridge at Green Lodge Street.                              | 20 |
| 1.79      | .0000       | .0000     | 1.04             | 5,000                          | Bridge at Milton Street.                                   | 21 |
| 2.15      | .0030       | .0000     | 1.02             | 7,000                          | Above Mother Brook.                                        | 22 |
| 0.53      | .0060       | .0000     | 0.76             | 17,000                         | Mother Brook.                                              | 23 |
| 1.09      | .0100       | .0000     | 0.94             | 22,000                         | Below Mother Brook.                                        | 24 |
| 1.41      | .0070       | .0002     | 0.72             | 11,000                         | Below Mother Brook.                                        | 25 |
| 2.39      | .0070       | .0004     | 0.90             | 6,000                          | Above Mattapan paper-mills.                                | 26 |
| 2.40      | .0050       | .0004     | 0.96             | 7,000                          | Below Boston Gossamer Rubber Company.                      | 27 |
| 2.41      | .0090       | .0004     | 0.98             | 7,000                          | Dam above Blue Hill Avenue, Mattapan.                      | 28 |
| 1.47      | .0070       | .0008     | 0.82             | 5,000                          | Above Tileston & Hollingsworth paper-mill.                 | 29 |
| 451.25    | .0130       | .0014     | 1.12             | 6,000                          | Tide water below Milton.                                   | 30 |

River, about 100 feet above the point where the sewer from Smith's Tannery enters the river; No. 16398, from the sewer leading from Smith's Tannery to the river; Nos. 16394 and 16426, from the river, 100 feet below the point where the sewer from Smith's Tannery enters it; No. 16427, from the river, just above the mouth of the Canton River; No. 16428, from the Canton River, about 100 feet above its confluence with the Neponset River; No. 16429, from the Neponset River, 1,000 feet below its confluence with the Canton River; No. 16430, from the Neponset River, where it is crossed by the Dedham Road; No. 16431, from the river, at Green Lodge Street; No. 16432, from the river, where it is crossed by Milton Street, just above Hyde Park; No. 16433, from the river, 100 feet above the outlet of Mother Brook; No. 16434, from Mother Brook; Nos. 16435 and 16436, from the Neponset River, about 1,000 feet below the point where it is joined by Mother Brook; No. 16437, at the dam of the paper-mill of Hollingsworth & Vose, below Hyde Park; No. 16438, below the factory of the Boston Gossamer Rubber Company; No. 16439, at the dam just above Blue Hill Avenue in Mattapan; No. 16440, at the dam of the paper-mill of Tileston & Hollingsworth; No. 16437, from the tide-water at Godfrey's wharf, below Milton.

**NEPONSET RIVER.**

*Chemical Examination of Water from the Neponset River below the Outlet of the Sewer from Smith's Tannery, Norwood.*

[Parts per 100,000.]

| Number. | Date of Collection.                            | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   |
|---------|------------------------------------------------|-------------|-----------|--------|-------------------------|-------------------|
|         |                                                | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. |
| 16731*  | Oct. 9, at 6, 7.30, 9 and 11 P.M., . .         | Decided.    | Heavy.    | 0.99   | 50.20                   | 13.50             |
| 16732   | Oct. 10, at 4.50, 6, 7.30 and 9 A.M., .        | Decided.    | Heavy.    | 0.88   | 36.10                   | 9.90              |
| 16733   | Oct. 10, at 10.30 A.M., 12 M., 1.30 and 3 P.M. | Decided.    | Heavy.    | 0.92   | 48.70                   | 14.10             |
| 16734   | Oct. 10, at 4.15 P.M., . . . .                 | Decided.    | Heavy.    | 1.00   | 53.00                   | 14.00             |

*Chemical Examination of Water from the Neponset River below the Outlet of the Sewer from Smith's Tannery, Norwood — Concluded.*

[Parts per 100,000.]

| Number. | AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|---------|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|--------------------------------|
|         | Free.    | ALBUMINOID. |            |                 |           | Nitrates.   | Nitrites. |                  |                                |
|         |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |                                |
| 16731*  | .3000    | .2800       | .2080      | .0720           | 11.49     | .0040       | .0000     | 4.40             | 501,000                        |
| 16732   | .1100    | .1180       | .0920      | .0260           | 7.58      | .0030       | .0000     | 2.80             | 93,000                         |
| 16733   | .0900    | .1580       | .1200      | .0380           | 12.32     | .0030       | .0000     | 3.68             | 346,000                        |
| 16734   | .1980    | .2440       | .1920      | .0520           | 13.07     | .0050       | .0000     | 4.50             | 455,000                        |

The samples were collected from the river, 100 feet below the outlet of the sewer from Smith's Tannery.

*Chemical Examination of Water from the Neponset River above Hyde Park.*

[Parts per 100,000.]

| Number. | Date of Collection.                            | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   |
|---------|------------------------------------------------|-------------|-----------|--------|-------------------------|-------------------|
|         |                                                | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. |
| 16735*  | Oct. 9, at 6, 7.30, 9 and 11 P.M., . .         | Slight.     | Decided.  | 0.69   | 17.75                   | 5.80              |
| 16736   | Oct. 10, at 4.30, 6, 7.30 and 9 A.M., .        | Slight.     | Slight.   | 0.60   | 11.35                   | 4.65              |
| 16737   | Oct. 10, at 10.30 A.M., 12 M., 1.30 and 3 P.M. | Slight.     | Slight.   | 0.59   | 11.15                   | 3.00              |
| 16738   | Oct. 10, at 4.30 P.M., . . . .                 | Slight.     | Slight.   | 0.60   | -                       | -                 |

\* These analyses were made at the Lawrence Experiment Station.

## NEPONSET RIVER.

*Chemical Examination of Water from the Neponset River above Hyde Park — Concluded.*

[Parts per 100,000.]

| Number. | AMMONIA. |             |            |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|---------|----------|-------------|------------|-----------------|-----------|-------------|-----------|------------------|--------------------------------|
|         | Free.    | ALBUMINOID. |            |                 |           | Nitrates.   | Nitrites. |                  |                                |
|         |          | Total.      | Dissolved. | Sus-<br>pended. |           |             |           |                  |                                |
| 16735*  | .0698    | .0652       | .0598      | .0054           | 2.77      | .0040       | .0006     | 1.11             | 2,800                          |
| 16736   | .0372    | .0448       | .0428      | .0020           | 1.49      | .0070       | .0006     | 0.79             | 5,900                          |
| 16737   | .0412    | .0392       | .0376      | .0016           | 1.60      | .0070       | .0004     | 0.79             | 2,100                          |
| 16738   | .0528    | .0480       | .0424      | .0056           | 1.89      | .0040       | .0004     | 0.80             | 2,600                          |

The samples were collected from the river about 200 feet above Paul's bridge at Milton Street, above the thickly settled portion of the town of Hyde Park.

*Chemical Examination of Water from the Neponset River at Mattapan.*

[Parts per 100,000.]

| Number. | Date of Collection.                            | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   |
|---------|------------------------------------------------|-------------|-----------|--------|-------------------------|-------------------|
|         |                                                | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. |
| 16739*  | Oct. 9, at 6.30, 7.30, 9 and 11 P.M., .        | Slight.     | Decided.  | 0.52   | 16.25                   | 4.95              |
| 16740   | Oct. 10, at 4.30, 6, 7.30 and 9 A.M., .        | Slight.     | Decided.  | 0.52   | 20.30                   | 7.55              |
| 16741   | Oct. 10, at 10.30 A.M., 12 M., 1.30 and 3 P.M. | Slight.     | Decided.  | 0.52   | 17.40                   | 6.25              |
| 16742   | Oct. 10, at 4.30 P.M., . . . .                 | Slight.     | Decided.  | 0.54   | 17.10                   | 6.05              |

*Chemical Examination of Water from the Neponset River at Mattapan — Concluded.*

[Parts per 100,000.]

| Number. | AMMONIA. |             |           |                 | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|---------|----------|-------------|-----------|-----------------|-----------|-------------|-----------|------------------|--------------------------------|
|         | Free.    | ALBUMINOID. |           |                 |           | Nitrates.   | Nitrites. |                  |                                |
|         |          | Total.      | Dissolved | Sus-<br>pended. |           |             |           |                  |                                |
| 16739*  | .0700    | .0420       | .0360     | .0060           | 2.30      | .0040       | .0014     | 1.07             | 224,000                        |
| 16740   | .0640    | .0700       | .0400     | .0300           | 2.68      | .0040       | .0010     | 1.06             | 60,000                         |
| 16741   | .0620    | .0480       | .0480     | .0000           | 2.38      | .0040       | .0010     | 1.10             | 48,000                         |
| 16742   | .0620    | .0580       | .0500     | .0080           | 2.02      | .0040       | .0004     | 1.16             | 147,000                        |

The samples were collected from the river at the dam just above Blue Hill Avenue in Mattapan.

\* These analyses were made at the Lawrence Experiment Station.



## STONY BROOK.

## STONY BROOK.

*Chemical Examination of Water from Stony Brook, Boston.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 14548   | 1895.<br>June 27    | Slight.     | Cons.     | .25    | 11.45                   | 3.45              | .0018    | .0074       | .0062      | .0022      | 1.50      | .1000       | .0012     | .2487            | 4.0       |
| 14722   | July 29             | Slight.     | Cons.     | .40    | 10.50                   | 4.05              | .0038    | .0224       | .0170      | .0054      | 2.05      | .1050       | .0018     | .3385            | 4.3       |
| 14933   | Aug. 29             | V. slight.  | Cons.     | .33    | 12.45                   | 3.65              | .0256    | .0186       | .0152      | .0034      | 1.58      | .0600       | .0027     | .2262            | 4.8       |
| 15235   | Sept. 24            | V. slight.  | Slight.   | .60    | 12.35                   | 3.25              | .0099    | .0174       | .0138      | .0036      | 2.00      | .0580       | .0040     | .2746            | 4.2       |
| AV.     | .....               | .....       | .....     | .39    | 11.69                   | 3.60              | .0100    | .0164       | .0128      | .0036      | 1.78      | .0807       | .0024     | .2721            | 4.3       |

Odor, of the first two samples, faintly vegetable; of the last two, distinctly vegetable and mouldy. — The first two and last samples were collected  $1\frac{1}{2}$  miles above the Forest Hills railroad station, and the third sample at Forest Hills.

## TEN MILE RIVER.

*Chemical Examination of Water from the Ten Mile River, at Attleborough.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment. | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |           |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
|         | 1895.               |             |           |        |                         |                   |          |             |            |            |           |             |           |                  |           |
| 14675   | July 22             | Slight.     | Cons.     | 1.10   | 5.65                    | 2.50              | .0090    | .0298       | .0250      | .0048      | .52       | .0200       | .0007     | .8550            | 1.6       |
| 14676   | July 22             | Slight.     | Cons.     | 0.40   | 4.60                    | 1.75              | .0018    | .0238       | .0210      | .0028      | .56       | .0020       | .0001     | .3750            | 1.7       |

Odor, distinctly vegetable and unpleasant. — The first sample was collected from the river at West Street, just above the mouth of the Bungay River. The second sample was collected from the river about 1,000 feet below the railroad bridge on the main line of the Boston and Providence Railroad.

## WARE RIVER.

## WARE RIVER.

*Chemical Examination of Water from Ware River at Cold Brook Station, Barre.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |            |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.  | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |            |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 13599   | 1895.<br>Jan. 4     | V. slight.  | V. slight. | 0.65   | 5.70                    | 2.25              | .0038    | .0376       | .0360      | .0016      | .29       | .0100       | .0000     | 0.7715           | 1.6       |
| 13738   | Feb. 4              | V. slight.  | V. slight. | 0.60   | 4.45                    | 1.45              | .0028    | .0196       | .0156      | .0040      | .23       | .0120       | .0000     | 0.6873           | 1.3       |
| 13920   | Mar. 5              | V. slight.  | Slight.    | 0.57   | 3.95                    | 1.70              | .0030    | .0170       | .0146      | .0024      | .16       | .0070       | .0000     | 0.6314           | 1.1       |
| 14057   | Apr. 1              | Slight.     | Slight.    | 0.60   | 3.50                    | 1.50              | .0002    | .0174       | .0160      | .0014      | .13       | .0070       | .0000     | 0.6275           | 0.6       |
| 14219   | May 1               | V. slight.  | Slight.    | 0.80   | 3.20                    | 1.50              | .0002    | .0182       | .0154      | .0028      | .17       | .0030       | .0000     | 0.7700           | 0.8       |
| 14398   | June 3              | Slight.     | Slight.    | 1.20   | 3.45                    | 1.80              | .0026    | .0264       | .0252      | .0012      | .14       | .0040       | .0000     | 1.0336           | 1.1       |
| 14556   | July 1              | V. slight.  | Slight.    | 1.05   | 4.45                    | 2.10              | .0004    | .0216       | .0180      | .0036      | .12       | .0000       | .0001     | 0.8745           | 0.6       |
| 14766   | Aug. 5              | V. slight.  | Slight.    | 0.80   | 4.00                    | 1.75              | .0012    | .0236       | .0222      | .0014      | .16       | .0100       | .0001     | 0.8424           | 1.4       |
| 14961   | Sept. 3             | Distinct.   | Slight.    | 0.50   | 3.65                    | 1.05              | .0012    | .0196       | .0184      | .0012      | .16       | .0000       | .0001     | 0.5544           | 0.5       |
| 15293   | Oct. 1              | Slight.     | Slight.    | 0.60   | 3.30                    | 1.20              | .0000    | .0198       | .0188      | .0010      | .17       | .0030       | .0000     | 0.5242           | 0.6       |
| 15469   | Nov. 4              | Slight.     | Slight.    | 1.00   | 4.35                    | 2.40              | .0006    | .0242       | .0230      | .0012      | .18       | .0030       | .0001     | 1.1973           | 1.3       |
| 15672   | Dec. 4              | V. slight.  | V. slight. | 0.98   | 3.55                    | 1.70              | .0004    | .0176       | .0160      | .0016      | .14       | .0020       | .0000     | 1.0078           | 0.5       |
| Av.     | .....               | .....       | .....      | 0.78   | 3.96                    | 1.70              | .0014    | .0219       | .0199      | .0020      | .17       | .0051       | .0000     | 0.7985           | 0.9       |

Odor, vegetable. — The samples were collected from the river, at the railroad bridge near Cold Brook station, in the south-easterly part of the town of Barre.



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**SUMMARY**  
**OF**  
**WATER SUPPLY STATISTICS;**  
**ALSO**  
**RECORDS OF RAINFALL AND FLOW OF STREAMS.**

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## SUMMARY OF WATER SUPPLY STATISTICS.

During the year 1895 a public water supply was introduced for the first time into the towns of Barre, Longmeadow, Millbury, Monson and Rockport, and important additions to many of the existing works were made, to increase the capacity of existing sources of supply.

The following table gives a classification by population of cities and towns having and not having public water supplies December 31, 1895; the populations are taken from the census of 1895:—

| POPULATION<br>(1895).  | Number of<br>Places of Given<br>Population<br>having a Pub-<br>lic Water<br>Supply. | Total<br>Population of<br>Places<br>in Preceding<br>Column. | Number of<br>Places of Given<br>Population<br>not having a<br>Public<br>Water Supply. | Total<br>Population of<br>Places<br>in Preceding<br>Column. |
|------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------|---------------------------------------------------------------------------------------|-------------------------------------------------------------|
| Under 500, . . . . .   | 0                                                                                   | 0                                                           | 36                                                                                    | 13,287                                                      |
| 500-1,000, . . . . .   | 3                                                                                   | 2,323                                                       | 56                                                                                    | 43,481                                                      |
| 1,000-1,500, . . . . . | 9                                                                                   | 10,650                                                      | 38                                                                                    | 46,593                                                      |
| 1,500-2,000, . . . . . | 7                                                                                   | 12,115                                                      | 32                                                                                    | 55,861                                                      |
| 2,000-2,500, . . . . . | 10                                                                                  | 19,990                                                      | 14                                                                                    | 31,074                                                      |
| 2,500-3,000, . . . . . | 6                                                                                   | 16,873                                                      | 12                                                                                    | 32,618                                                      |
| 3,000-3,500, . . . . . | 10                                                                                  | 32,515                                                      | 7                                                                                     | 22,599                                                      |
| 3,500-4,000, . . . . . | 5                                                                                   | 18,219                                                      | 1                                                                                     | 3,509                                                       |
| 4,000-4,500, . . . . . | 7                                                                                   | 34,516                                                      | 2                                                                                     | 3,548                                                       |
| Above 4,500, . . . . . | 97                                                                                  | 2,089,816                                                   | 1                                                                                     | 6,039                                                       |
| TOTALS, . . . . .      | 154                                                                                 | 2,237,017                                                   | 199                                                                                   | 268,166                                                     |

From the totals given in the preceding table it will be seen that of the 353 cities and towns in the State 154, or 43.6 per cent., have a public water supply, and the total population of the places supplied represents 89.5 per cent. of the total population of the State. The number of people to whom a public water supply is available is somewhat less than the total population of the municipalities supplied, but the difference is not large. There are now but 11 towns having, by the

census of 1895, a population exceeding 3,000 which are not provided with a public water supply; these are given in the following table:—

| TOWNS.                   | Population in 1895. | TOWNS.                | Population in 1895. |
|--------------------------|---------------------|-----------------------|---------------------|
| Blackstone, . . . . .    | 6,039               | Pepperell, . . . . .  | 3,321               |
| Winchendon,* . . . . .   | 4,490               | Dudley, . . . . .     | 3,203               |
| Barnstable, . . . . .    | 4,055               | Chelmsford, . . . . . | 3,162               |
| North Andover, . . . . . | 3,569               | Dartmouth, . . . . .  | 3,107               |
| Sutton, . . . . .        | 3,420               | Deerfield, . . . . .  | 3,007               |
| Tewksbury, . . . . .     | 3,379               |                       |                     |

\* Works for the supply of this town were under construction at the end of 1894.

In the following table the various water supplies are classified according to the dates when a fairly complete system of supply was first introduced into a city or town:—

| YEARS.                          | Number of Places Supplied. | YEARS.           | Number of Places Supplied. |
|---------------------------------|----------------------------|------------------|----------------------------|
| Previous to 1850, . . . . .     | 6                          | 1891, . . . . .  | 5                          |
| 1850-1859, inclusive, . . . . . | 4                          | 1892, . . . . .  | 1                          |
| 1860-1869, inclusive, . . . . . | 10                         | 1893, . . . . .  | 3                          |
| 1870-1879, inclusive, . . . . . | 44                         | 1894, . . . . .  | 3                          |
| 1880-1889, inclusive, . . . . . | 68                         | 1895, . . . . .  | 5                          |
| 1890, . . . . .                 | 5                          | TOTAL, . . . . . | 154                        |

During the year 1895 the cities of Gloucester and Newburyport took possession of the works which were formerly owned by water companies. At the end of the year all of the 32 cities in the State, having an aggregate population of 1,616,632, owned their water works. Of the 123 towns having a public water supply, 77, with a total population of 407,806, own their works, while 46, having a total population of 212,579, are supplied by private companies. The total population in both cities and towns owning works is 2,240,438, against 212,579 in those supplied by private companies.

The growing tendency in recent years toward municipal control of water supplies is indicated by a comparison of the preceding

figures with similar figures for 1890. At that time 5 of the 28 cities in the State having public water supplies and 50 of the 109 towns were supplied by private companies. The total population of these cities and towns was 318,319, or 16 per cent. of the total population supplied, while in 1895 only 9.5 per cent. of the total population supplied was supplied by private companies.

The following table gives statistics with regard to the consumption of water in the cities and towns in this State where such records are kept. The consumption per inhabitant has been obtained by dividing the average daily consumption by the total population of the city or town in 1895, and consequently is somewhat less than the amount used per consumer, because there are in all cities and towns some who do not use the public water supply. This difference is most marked in towns containing villages to which the public water supply has not been extended, and in towns where the works have been in operation but a short time and where water has not come into general use. In some towns the population during the summer months is much greater than is shown by the census returns, and in such cases the consumption per inhabitant as given in the table is somewhat higher than it would be if allowance should be made for the increased population in summer.

*Statistics relating to the Consumption of Water in Various Cities and Towns.*

| CITY OR TOWN.                                        | Population.<br>1895. | Average<br>Daily<br>Consumption.<br>Gallons.<br>1895. | Daily<br>Consumption<br>per<br>Inhabitant.<br>Gallons.<br>1895. | CITY OR TOWN.          | Population.<br>1895. | Average<br>Daily<br>Consumption.<br>Gallons.<br>1895. | Daily<br>Consumption<br>per<br>Inhabitant.<br>Gallons.<br>1895. |
|------------------------------------------------------|----------------------|-------------------------------------------------------|-----------------------------------------------------------------|------------------------|----------------------|-------------------------------------------------------|-----------------------------------------------------------------|
| Abington and Rockland.                               | 9,730                | 407,000                                               | 42                                                              | Broekton, . .          | 33,165               | 1,095,000                                             | 33                                                              |
| Amesbury, . .                                        | 9,986                | 239,000                                               | 24                                                              | Brookline, . .         | 16,164               | 1,308,000                                             | 81                                                              |
| Andover, . .                                         | 6,145                | 331,000                                               | 54                                                              | Cambridge, . .         | 81,643               | 6,073,000                                             | 74                                                              |
| Attleborough, .                                      | 8,288                | 306,000                                               | 37                                                              | Canton, . . .          | 4,636                | 179,000                                               | 39                                                              |
| Avon, . . .                                          | 1,626                | 62,000                                                | 38                                                              | Cohasset, . .          | 2,474                | 66,000                                                | 26                                                              |
| Ayer, . . .                                          | 2,101                | 73,000                                                | 35                                                              | Cottage City, .        | 1,038                | 58,000                                                | 56                                                              |
| Beverly, . .                                         | 11,806               | 810,000                                               | 69                                                              | Danvers and Middleton. | 9,019                | 606,000                                               | 67                                                              |
| Boston (Cochituate Works).                           | 456,616              | 50,801,100                                            | 112                                                             | Dedham, . .            | 7,211                | 411,000                                               | 57                                                              |
| Boston, Somerville, Chelsea, Everett (Myatie Works). | 142,341              | 9,467,000                                             | 66                                                              | Easton, . . .          | 4,452                | 82,000                                                | 18                                                              |
| Bradford, . .                                        | 4,736                | 473,000                                               | 100                                                             | Fairhaven, . .         | 3,338                | 70,000                                                | 21                                                              |
| Braintree, . .                                       | 5,311                | 308,000                                               | 58                                                              | Fall River, . .        | 89,203               | 3,167,000                                             | 35                                                              |
| Bridgewater and E. Bridgewater.                      | 7,580                | 164,000                                               | 22                                                              | Foxborough, . .        | 3,219                | 141,000                                               | 44                                                              |
|                                                      |                      |                                                       |                                                                 | Framingham, .          | 9,512                | 362,000                                               | 38                                                              |



*Statistics relating to the Consumption of Water in various Cities and Towns —*  
Concluded.

| CITY OR TOWN.      | Popula-<br>tion.<br>1895. | Average<br>Daily<br>Consump-<br>tion.<br>Gallons.<br>1895. | Daily<br>Consump-<br>tion per<br>Inhabit-<br>tant.<br>Gallons.<br>1895. | CITY OR TOWN.                       | Popula-<br>tion.<br>1895. | Average<br>Daily<br>Consump-<br>tion.<br>Gallons.<br>1895. | Daily<br>Consump-<br>tion per<br>Inhabit-<br>tant.<br>Gallons.<br>1895. |
|--------------------|---------------------------|------------------------------------------------------------|-------------------------------------------------------------------------|-------------------------------------|---------------------------|------------------------------------------------------------|-------------------------------------------------------------------------|
| Franklin, . .      | 5,136                     | 201,000                                                    | 39                                                                      | Newburyport, .                      | 14,552                    | 667,000                                                    | 46                                                                      |
| Gardner, . .       | 9,182                     | 504,000                                                    | 55                                                                      | Newton, . . .                       | 27,590                    | 1,802,000                                                  | 65                                                                      |
| Gloucester, . .    | 28,211                    | 739,000                                                    | 26                                                                      | No. Attleborough,                   | 6,576                     | 183,000                                                    | 28                                                                      |
| Grafton, . . .     | 5,101                     | 85,000                                                     | 17                                                                      | North Brookfield, .                 | 4,635                     | 92,000                                                     | 20                                                                      |
| Holliston, . .     | 2,718                     | 79,000                                                     | 29                                                                      | Norwood, . . .                      | 4,574                     | 268,000                                                    | 59                                                                      |
| Hopkinton, . .     | 2,984                     | 33,000                                                     | 11                                                                      | Orange, . . . .                     | 5,361                     | 138,000                                                    | 26                                                                      |
| Hyde Park, . .     | 11,826                    | 482,000                                                    | 41                                                                      | Peabody, . . .                      | 10,507                    | 900,000                                                    | 86                                                                      |
| Lawrence, . .      | 52,164                    | 3,006,000                                                  | 57                                                                      | Provincetown, .                     | 4,555                     | 65,850                                                     | 15                                                                      |
| Lexington, . .     | 3,498                     | 136,000                                                    | 39                                                                      | Quincy, . . . .                     | 20,712                    | 904,000                                                    | 44                                                                      |
| Longmeadow, .      | 620                       | 23,000                                                     | 37                                                                      | Randolph and Hol-<br>brook, . . . . | 5,992                     | 273,000                                                    | 46                                                                      |
| Lowell, . . . .    | 84,367                    | 6,926,000                                                  | 82                                                                      | Reading, . . . .                    | 4,717                     | 199,000                                                    | 42                                                                      |
| Lynn and Saugus, . | 66,851                    | 4,360,000                                                  | 65                                                                      | Revere and Win-<br>throp, . . . .   | 11,615                    | 874,000                                                    | 75                                                                      |
| Malden, . . . .    | 29,708                    | 1,471,000                                                  | 49                                                                      | Rockport, . . .                     | 5,289                     | 85,000                                                     | 16                                                                      |
| Manchester, . .    | 1,876                     | 116,000                                                    | 62                                                                      | Salem, . . . . .                    | 34,473                    | 2,163,000                                                  | 63                                                                      |
| Mansfield, . .     | 3,722                     | 126,000                                                    | 34                                                                      | Sharon, . . . .                     | 1,717                     | 36,000                                                     | 21                                                                      |
| Marblehead, . .    | 7,671                     | 268,000                                                    | 35                                                                      | Stoughton, . . .                    | 5,272                     | 246,000                                                    | 47                                                                      |
| Marlborough, .     | 14,977                    | 510,000                                                    | 34                                                                      | Swampscott and<br>Nahant, . . . .   | 4,124                     | 408,000                                                    | 99                                                                      |
| Maynard, . . .     | 3,090                     | 78,000                                                     | 25                                                                      | Taunton, . . . .                    | 27,115                    | 1,159,000                                                  | 43                                                                      |
| Melrose, . . .     | 11,965                    | 849,000                                                    | 71                                                                      | Tisbury, . . . .                    | 1,002                     | 23,000                                                     | 23                                                                      |
| Methuen, . . .     | 5,690                     | 149,000                                                    | 26                                                                      | Wakefield and<br>Stoneham, . . .    | 14,588                    | 612,000                                                    | 42                                                                      |
| Middleborough, .   | 6,689                     | 213,000                                                    | 32                                                                      | Waltham, . . . .                    | 20,876                    | 1,222,000                                                  | 59                                                                      |
| Milford, . . . .   | 8,959                     | 527,000                                                    | 59                                                                      | Ware, . . . . .                     | 7,651                     | 241,000                                                    | 31                                                                      |
| Milton, . . . .    | 5,518                     | 133,000                                                    | 24                                                                      | Watertown and<br>Belmont, . . . .   | 10,631                    | 428,000                                                    | 40                                                                      |
| Montague, . . .    | 6,058                     | 320,000                                                    | 53                                                                      | Webster, . . . .                    | 7,799                     | 209,000                                                    | 27                                                                      |
| Nantucket, . . .   | 3,016                     | 89,000                                                     | 30                                                                      | Wellesley, . . .                    | 4,229                     | 175,000                                                    | 42                                                                      |
| Natick, . . . .    | 8,814                     | 382,000                                                    | 43                                                                      | Weymouth, . . .                     | 11,291                    | 286,000                                                    | 25                                                                      |
| Needham, . . .     | 3,511                     | 139,000                                                    | 40                                                                      | Whitman, . . . .                    | 5,744                     | 187,000                                                    | 32                                                                      |
| New Bedford, .     | 55,251                    | 4,712,000                                                  | 85                                                                      | Woburn, . . . .                     | 14,173                    | 1,032,000                                                  | 73                                                                      |

## RAINFALL.

The rainfall for the year 1895 was very slightly less than normal, the deficiency being 0.63 of an inch. There was an excess of rainfall in the months of April, July, October and November, and a deficiency in all the remaining months, the greatest deficiency occurring in February. The greatest excess occurred in the months of October and November. An exceptionally heavy rainfall occurred in the eastern part of the State from October 12 to 14, the greatest amount recorded being 8.49 inches at Framingham. The distribution of rainfall was such as to cause a very low flow in the streams in the latter part of August, in September and in the earlier portion of October. The average rainfall in Massachusetts, as deduced from long-continued observations in various parts of the State, is 45.30 inches. In the following table is given the normal rainfall in each month in 1895 and departures from the normal : \* —

|                 | Normal<br>Rainfall.<br>Inches. | Rainfall,<br>1895.<br>Inches. | Excess or<br>Deficiency.<br>Inches. |                     | Normal<br>Rainfall.<br>Inches. | Rainfall,<br>1895.<br>Inches. | Excess or<br>Deficiency<br>Inches. |
|-----------------|--------------------------------|-------------------------------|-------------------------------------|---------------------|--------------------------------|-------------------------------|------------------------------------|
| <b>1895.</b>    |                                |                               |                                     | <b>1895.</b>        |                                |                               |                                    |
| January, . . .  | 3.97                           | 3.51                          | —0.46                               | August, . . .       | 4.42                           | 3.37                          | —1.05                              |
| February, . . . | 3.64                           | 1.07                          | —2.57                               | September, . . .    | 3.38                           | 2.69                          | —0.71                              |
| March, . . .    | 3.87                           | 2.91                          | —0.96                               | October, . . .      | 4.13                           | 7.16                          | +3.03                              |
| April, . . .    | 3.34                           | 4.67                          | +1.33                               | November, . . .     | 4.06                           | 6.23                          | +2.22                              |
| May, . . .      | 3.72                           | 2.47                          | —1.25                               | December, . . .     | 3.71                           | 2.96                          | —0.75                              |
| June, . . .     | 3.20                           | 3.08                          | —0.12                               |                     |                                |                               |                                    |
| July, . . .     | 3.86                           | 4.51                          | +0.65                               | <b>TOTAL, . . .</b> | <b>45.30</b>                   | <b>44.67</b>                  | <b>—0.63</b>                       |

To enable the condition preceding the collection of samples of water in any part of the State to be understood, the following tables are presented, which give the daily rainfall in inches at nine stations scattered throughout the State : —

\* This and the subsequent tables of rainfall have been prepared from the records of the New England Weather Service.

*Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected.*

| January, 1895.      |         |          |            |             |                |           |        |          |              | February, 1895.     |         |          |            |             |                |           |        |          |              |
|---------------------|---------|----------|------------|-------------|----------------|-----------|--------|----------|--------------|---------------------|---------|----------|------------|-------------|----------------|-----------|--------|----------|--------------|
| DAY<br>OF<br>MONTH. | Ludlow. | Amherst. | Fitchburg. | Framingham. | Chestnut Hill. | Lawrence. | Salem. | Taunton. | New Bedford. | DAY<br>OF<br>MONTH. | Ludlow. | Amherst. | Fitchburg. | Framingham. | Chestnut Hill. | Lawrence. | Salem. | Taunton. | New Bedford. |
| 1, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            | 1, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 2, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            | 2, . .              | 0.09    | 0.12     | 0.07       | 0.15        | 0.20           | 0.06      | 0.18   | 0.25     | 0.30         |
| 3, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            | 3, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 4, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            | 4, . .              | 0.07    | 0.01     | 0.11       | 0.14        | 0.25           | 0.09      | *      | 0.14     | 0.17         |
| 5, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            | 5, . .              | -       | -        | -          | -           | -              | -         | 0.15   | -        | -            |
| 6, . .              | 0.40    | *        | 0.71       | *           | *              | 0.41      | *      | *        | *            | 6, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 7, . .              | 0.10    | *        | -          | 0.56        | 0.49           | -         | 0.34   | 0.67     | 0.93         | 7, . .              | *       | *        | *          | *           | *              | *         | *      | *        | *            |
| 8, . .              | 0.21    | 1.03     | 0.07       | *           | 0.25           | -         | 0.01   | -        | *            | 8, . .              | 0.90    | 0.47     | 1.06       | 1.13        | 0.38           | 0.84      | 0.90   | 0.82     | 0.32         |
| 9, . .              | -       | -        | 0.03       | 0.25        | -              | 0.17      | 0.24   | 0.29     | 0.22         | 9, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 10, . .             | -       | *        | 0.30       | *           | *              | *         | *      | *        | *            | 10, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 11, . .             | 0.70    | 0.85     | 0.47       | 1.02        | 1.08           | 0.84      | 0.76   | 1.05     | 0.72         | 11, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 12, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 12, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 13, . .             | -       | 0.07     | 0.06       | 0.07        | 0.08           | 0.02      | 0.05   | 0.08     | 0.10         | 13, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 14, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 14, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 15, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 15, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 16, . .             | 0.13    | 0.31     | 0.32       | 0.46        | 0.50           | 0.38      | 0.43   | 0.60     | *            | 16, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 17, . .             | -       | -        | -          | -           | -              | -         | -      | -        | 0.61         | 17, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 18, . .             | *       | *        | -          | 0.20        | 0.18           | -         | 0.08   | -        | -            | 18, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 19, . .             | 0.20    | 0.23     | 0.10       | -           | -              | 0.05      | -      | 0.20     | 0.18         | 19, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 20, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 20, . .             | -       | 0.06     | -          | -           | -              | -         | -      | -        | -            |
| 21, . .             | 0.15    | *        | 0.16       | *           | *              | *         | *      | *        | *            | 21, . .             | -       | -        | 0.02       | -           | 0.05           | -         | -      | -        | 0.04         |
| 22, . .             | -       | 0.22     | 0.04       | 0.24        | 0.24           | 0.29      | 0.32   | 0.23     | 0.31         | 22, . .             | -       | -        | 0.02       | 0.03        | -              | -         | -      | -        | -            |
| 23, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 23, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 24, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 24, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 25, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 25, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 26, . .             | 0.13    | 0.49     | 1.03       | 0.92        | 0.93           | 1.02      | 1.49   | 0.95     | 0.54         | 26, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 27, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 27, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 28, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 28, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 29, . .             | 0.08    | 0.04     | 0.03       | 0.16        | 0.16           | 0.08      | 0.12   | 0.17     | 0.24         |                     |         |          |            |             |                |           |        |          |              |
| 30, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |                     |         |          |            |             |                |           |        |          |              |
| 31, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |                     |         |          |            |             |                |           |        |          |              |
| TOTALS,             | 2.10    | 3.24     | 3.32       | 3.88        | 3.91           | 3.26      | 3.84   | 4.24     | 3.85         | TOTALS,             | 1.06    | 0.66     | 1.28       | 1.45        | 0.88           | 0.99      | 1.23   | 1.21     | 0.83         |

\* Precipitation included in that of following day.

*Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected*  
— Continued.

| March, 1895.        |         |          |            |             |                |           |        |          |              | April, 1895.        |         |          |            |             |                |           |        |          |              |
|---------------------|---------|----------|------------|-------------|----------------|-----------|--------|----------|--------------|---------------------|---------|----------|------------|-------------|----------------|-----------|--------|----------|--------------|
| DAY<br>OF<br>MONTH. | Ludlow. | Amherst. | Fitchburg. | Framingham. | Chestnut Hill. | Lawrence. | Salem. | Taunton. | New Bedford. | DAY<br>OF<br>MONTH. | Ludlow. | Amherst. | Fitchburg. | Framingham. | Chestnut Hill. | Lawrence. | Salem. | Taunton. | New Bedford. |
| 1, .                | -       | *        | -          | -           | -              | -         | -      | -        | -            | 1, .                | -       | -        | -          | -           | *              | -         | *      | 0.01     |              |
| 2, .                | 0.40    | 0.48     | 0.34       | 0.69        | 0.52           | -         | 0.52   | 0.60     | 0.54         | 2, .                | -       | -        | -          | -           | 0.01           | -         | 0.04   | 0.10     |              |
| 3, .                | -       | -        | -          | -           | -              | -         | -      | -        | 0.08         | 3, .                | 0.20    | -        | 0.23       | 0.39        | -              | 0.35      | 0.43   | 0.36     | 0.38         |
| 4, .                | 0.30    | 0.30     | *          | 0.11        | 0.07           | 0.08      | -      | *        | -            | 4, .                | -       | -        | -          | -           | 0.44           | -         | -      | -        | -            |
| 5, .                | -       | -        | 0.28       | -           | -              | -         | 0.08   | 0.12     | 0.07         | 5, .                | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 6, .                | 0.10    | 0.25     | 0.18       | 0.09        | 0.11           | *         | 0.09   | -        | -            | 6, .                | 0.20    | -        | -          | -           | -              | -         | -      | -        | -            |
| 7, .                | *       | *        | 0.18       | *           | *              | 0.19      | *      | *        | *            | 7, .                | -       | -        | -          | -           | -              | -         | -      | -        | 0.10         |
| 8, .                | 0.47    | 0.42     | 0.18       | 0.85        | 0.79           | 0.51      | 0.74   | 1.08     | 1.17         | 8, .                | 1.03    | 1.90     | 0.14       | -           | -              | -         | -      | *        | -            |
| 9, .                | -       | -        | -          | -           | -              | -         | 0.03   | -        | 0.09         | 9, .                | -       | 0.30     | 1.22       | *           | 0.94           | 0.70      | 0.95   | 1.59     | 1.82         |
| 10, .               | -       | -        | -          | -           | -              | -         | -      | -        | -            | 10, .               | 2.00    | -        | 0.07       | 1.29        | 0.26           | 0.11      | -      | 0.39     | 0.50         |
| 11, .               | -       | -        | -          | -           | -              | -         | -      | -        | -            | 11, .               | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 12, .               | 0.50    | *        | 0.01       | 0.04        | -              | -         | -      | -        | -            | 12, .               | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 13, .               | -       | 0.70     | 0.06       | *           | -              | -         | *      | -        | -            | 13, .               | 0.50    | -        | 0.43       | *           | *              | *         | 1.36   | *        | *            |
| 14, .               | -       | -        | 0.81       | 0.76        | 0.80           | 0.89      | 1.10   | 1.23     | 1.62         | 14, .               | -       | -        | 2.12       | 2.82        | 2.46           | *         | 0.09   | 2.06     | 1.48         |
| 15, .               | 0.03    | -        | 0.08       | *           | *              | *         | 0.10   | *        | *            | 15, .               | 0.50    | 1.71     | 0.11       | *           | *              | 3.21      | 0.08   | -        | *            |
| 16, .               | -       | -        | -          | 0.08        | 0.16           | 0.11      | -      | 0.28     | 0.52         | 16, .               | -       | -        | -          | 0.14        | 0.05           | 0.03      | -      | 0.32     | 0.15         |
| 17, .               | -       | -        | -          | -           | -              | -         | -      | -        | -            | 17, .               | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 18, .               | -       | -        | -          | -           | -              | -         | -      | -        | -            | 18, .               | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 19, .               | -       | -        | -          | -           | -              | -         | -      | -        | -            | 19, .               | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 20, .               | -       | -        | -          | -           | -              | -         | -      | -        | -            | 20, .               | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 21, .               | -       | -        | -          | -           | -              | -         | -      | -        | -            | 21, .               | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 22, .               | -       | -        | -          | -           | 0.02           | -         | -      | -        | -            | 22, .               | 0.15    | 0.11     | 0.02       | 0.20        | 0.17           | *         | *      | 0.41     | *            |
| 23, .               | -       | -        | -          | -           | -              | -         | -      | -        | -            | 23, .               | -       | -        | -          | -           | -              | 0.10      | 0.21   | -        | 0.25         |
| 24, .               | -       | -        | -          | -           | -              | -         | -      | -        | 0.01         | 24, .               | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 25, .               | 0.05    | 0.11     | 0.14       | 0.12        | 0.13           | 0.13      | 0.10   | 0.11     | 0.10         | 25, .               | -       | -        | -          | 0.03        | -              | -         | -      | 0.06     | -            |
| 26, .               | 0.02    | -        | -          | -           | -              | -         | -      | 0.03     | 0.01         | 26, .               | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 27, .               | -       | 0.15     | -          | -           | -              | -         | -      | -        | -            | 27, .               | 1.44    | 0.28     | 0.19       | 0.29        | 0.15           | *         | 0.10   | *        | 0.01         |
| 28, .               | 0.20    | -        | 0.22       | 0.14        | 0.25           | 0.31      | 0.31   | 0.27     | 0.25         | 28, .               | 0.05    | -        | -          | -           | -              | 0.17      | -      | 0.25     | 0.99         |
| 29, .               | 0.07    | 0.20     | -          | -           | -              | -         | 0.05   | -        | -            | 29, .               | 0.10    | -        | -          | 0.19        | -              | -         | -      | -        | -            |
| 30, .               | -       | -        | 0.08       | 0.07        | 0.06           | 0.10      | -      | 0.02     | 0.03         | 30, .               | -       | 0.17     | 0.20       | 0.03        | 0.13           | 0.26      | 0.14   | 0.08     | 0.24         |
| 31, .               | -       | -        | -          | -           | -              | -         | -      | -        | -            |                     |         |          |            |             |                |           |        |          |              |
| TOTALS,             | 2.14    | 2.61     | 2.55       | 2.95        | 2.91           | 2.32      | 3.12   | 3.74     | 4.49         | TOTALS,             | 6.17    | 4.47     | 4.73       | 5.38        | 4.60           | 4.94      | 3.36   | 5.55     | 5.81         |

\* Precipitation included in that of following day.

*Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected*  
— Continued.

| May, 1895.          |         |          |            |             |                |           |        |          |              | June, 1895.         |         |          |            |             |                |           |        |          |              |
|---------------------|---------|----------|------------|-------------|----------------|-----------|--------|----------|--------------|---------------------|---------|----------|------------|-------------|----------------|-----------|--------|----------|--------------|
| DAY<br>OF<br>MONTH. | Ludlow. | Amherst. | Fitchburg. | Framingham. | Chestnut Hill. | Lawrence. | Salem. | Taunton. | New Bedford. | DAY<br>OF<br>MONTH. | Ludlow. | Amherst. | Fitchburg. | Framingham. | Chestnut Hill. | Lawrence. | Salem. | Taunton. | New Bedford. |
| 1, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            | 1, . .              | -       | -        | -          | 0.51        | 0.29           | 0.19      | -      | -        | 0.13         |
| 2, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            | 2, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 3, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            | 3, . .              | -       | -        | 0.06       | *           | *              | *         | 0.10   | 0.11     | 0.12         |
| 4, . .              | -       | -        | -          | -           | 0.09           | 0.10      | *      | -        | -            | 4, . .              | 1.20    | -        | 0.28       | *           | 0.11           | 0.09      | -      | 0.16     | 0.39         |
| 5, . .              | -       | -        | -          | -           | -              | -         | 0.28   | -        | 0.23         | 5, . .              | -       | *        | -          | *           | -              | *         | -      | *        | -            |
| 6, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            | 6, . .              | 0.40    | 1.58     | 0.10       | 0.55        | 0.12           | 0.19      | 0.12   | 0.06     | 0.13         |
| 7, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            | 7, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 8, . .              | 0.06    | 0.21     | 0.06       | -           | -              | -         | -      | -        | -            | 8, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 9, . .              | -       | -        | -          | 0.06        | -              | -         | -      | 0.05     | 0.01         | 9, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 10, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 10, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 11, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 11, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 12, . .             | 0.60    | 0.50     | 0.72       | *           | *              | -         | *      | 0.89     | 0.77         | 12, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 13, . .             | -       | -        | -          | 0.67        | 1.19           | 0.79      | 1.20   | 0.18     | 0.29         | 13, . .             | -       | -        | 0.40       | 0.16        | -              | -         | -      | -        | -            |
| 14, . .             | -       | -        | -          | -           | -              | -         | -      | *        | *            | 14, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 15, . .             | 0.30    | 0.12     | 0.48       | 0.57        | 0.65           | 0.20      | 0.63   | 1.20     | 0.96         | 15, . .             | -       | -        | -          | 0.03        | -              | -         | -      | -        | -            |
| 16, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 16, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 17, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 17, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 18, . .             | 0.15    | 0.15     | 0.07       | 0.26        | 0.25           | 0.13      | 0.21   | 0.40     | 0.52         | 18, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 19, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 19, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 20, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 20, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 21, . .             | -       | -        | -          | -           | -              | -         | 0.03   | *        | *            | 21, . .             | -       | -        | -          | 0.03        | -              | -         | -      | -        | -            |
| 22, . .             | -       | -        | -          | -           | -              | -         | -      | 0.31     | 0.65         | 22, . .             | -       | 0.15     | 0.11       | -           | 0.02           | -         | -      | -        | -            |
| 23, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 23, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 24, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 24, . .             | -       | 0.18     | -          | -           | -              | -         | -      | -        | -            |
| 25, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 25, . .             | -       | -        | 0.95       | 0.67        | 0.27           | 0.81      | 0.27   | 0.36     | 1.07         |
| 26, . .             | 0.20    | *        | 0.20       | 0.08        | 0.10           | *         | 0.13   | 0.20     | 0.49         | 26, . .             | 0.30    | -        | -          | -           | -              | -         | -      | -        | -            |
| 27, . .             | 0.70    | 1.00     | 0.79       | 0.28        | 0.30           | 0.11      | -      | 0.40     | 0.20         | 27, . .             | 0.25    | 0.80     | 0.43       | -           | *              | -         | *      | *        | *            |
| 28, . .             | -       | -        | -          | -           | -              | 0.22      | *      | -        | -            | 28, . .             | 0.40    | -        | 0.89       | -           | 1.17           | -         | 2.30   | 1.46     | 1.60         |
| 29, . .             | -       | -        | -          | -           | -              | -         | 0.21   | -        | -            | 29, . .             | 0.30    | 0.55     | -          | 1.15        | -              | 1.62      | -      | -        | -            |
| 30, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 30, . .             | -       | 0.21     | 0.02       | 0.13        | 0.23           | 0.04      | 0.19   | 0.02     | -            |
| 31, . .             | 0.05    | 0.06     | -          | 0.06        | -              | -         | 0.11   | 0.32     | 0.02         |                     |         |          |            |             |                |           |        |          |              |
| TOTALS,             | 2.05    | 2.03     | 2.32       | 1.94        | 2.58           | 1.55      | 2.80   | 3.95     | 4.23         | TOTALS,             | 2.85    | 3.47     | 3.24       | 3.23        | 2.21           | 2.94      | 2.95   | 2.17     | 3.54         |

\* Precipitation included in that of following day.

*Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected*  
— Continued.

| July, 1895.         |         |          |            |             |                |           |        |          |              | August, 1895.       |         |          |            |             |                |           |        |          |              |
|---------------------|---------|----------|------------|-------------|----------------|-----------|--------|----------|--------------|---------------------|---------|----------|------------|-------------|----------------|-----------|--------|----------|--------------|
| DAY<br>OF<br>MONTH. | Ludlow. | Amherst. | Fitchburg. | Framingham. | Chestnut Hill. | Lawrence. | Salem. | Taunton. | New Bedford. | DAY<br>OF<br>MONTH. | Ludlow. | Amherst. | Fitchburg. | Framingham. | Chestnut Hill. | Lawrence. | Salem. | Taunton. | New Bedford. |
| 1, . .              | -       | -        | 0.06       | -           | -              | 0.07      | 0.05   | 0.06     | 0.55         | 1, . .              | -       | 0.04     | -          | -           | -              | -         | -      | -        | -            |
| 2, . .              | 0.20    | -        | -          | -           | -              | -         | -      | -        | -            | 2, . .              | -       | -        | -          | 0.16        | 0.01           | 0.03      | 0.20   | 0.05     | -            |
| 3, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            | 3, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 4, . .              | 0.30    | -        | 0.05       | 0.32        | 0.50           | *         | *      | 0.75     | 0.75         | 4, . .              | -       | -        | 0.02       | -           | -              | -         | -      | -        | -            |
| 5, . .              | -       | -        | 0.06       | *           | -              | 0.06      | 0.16   | -        | -            | 5, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 6, . .              | *       | 0.36     | 0.44       | 0.80        | 0.40           | 0.19      | 0.04   | 0.41     | 0.60         | 6, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 7, . .              | 0.60    | -        | -          | -           | -              | -         | -      | -        | -            | 7, . .              | 0.30    | 0.38     | 0.34       | 1.84        | 1.48           | 0.36      | 2.32   | 0.83     | 0.62         |
| 8, . .              | -       | -        | -          | -           | -              | -         | 0.04   | -        | -            | 8, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 9, . .              | -       | 0.83     | 4.13       | 0.40        | 1.31           | 0.81      | 1.35   | 0.86     | 0.10         | 9, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 10, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 10, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 11, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 11, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 12, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 12, . .             | -       | 0.20     | 0.26       | 0.80        | 0.44           | 0.31      | 0.18   | 0.79     | 1.06         |
| 13, . .             | 1.20    | 0.44     | 0.28       | 0.43        | 0.45           | 0.54      | *      | 0.26     | 0.40         | 13, . .             | -       | -        | 0.04       | -           | -              | -         | -      | -        | -            |
| 14, . .             | -       | -        | 0.04       | 0.08        | -              | 0.21      | 0.51   | -        | 0.74         | 14, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 15, . .             | -       | -        | -          | -           | -              | -         | 0.07   | -        | -            | 15, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 16, . .             | -       | 0.23     | 0.10       | 0.06        | 0.05           | *         | *      | 0.53     | 0.24         | 16, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 17, . .             | -       | -        | -          | -           | -              | 0.03      | 0.07   | -        | -            | 17, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 18, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 18, . .             | 1.50    | 1.70     | 0.77       | 1.21        | 1.17           | 1.44      | 1.67   | 1.21     | 0.77         |
| 19, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 19, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 20, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 20, . .             | -       | -        | -          | 0.03        | -              | -         | -      | -        | -            |
| 21, . .             | -       | 0.27     | -          | -           | -              | -         | -      | -        | -            | 21, . .             | -       | -        | -          | -           | -              | -         | -      | -        | 0.04         |
| 22, . .             | 0.90    | -        | -          | 0.38        | 0.18           | 0.13      | 0.02   | -        | 0.06         | 22, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 23, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 23, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 24, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 24, . .             | *       | -        | 0.08       | 0.01        | 0.01           | 0.09      | -      | -        | -            |
| 25, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 25, . .             | 0.10    | -        | -          | -           | -              | -         | -      | -        | -            |
| 26, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 26, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 27, . .             | 2.20    | 1.02     | 0.31       | 0.12        | -              | *         | *      | -        | *            | 27, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 28, . .             | -       | -        | 0.34       | -           | 0.03           | 0.30      | 0.09   | 0.23     | 0.02         | 28, . .             | 0.10    | 0.42     | -          | 0.18        | -              | -         | -      | 0.19     | 0.02         |
| 29, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            | 29, . .             | -       | -        | 0.14       | 0.02        | 0.08           | 0.02      | -      | -        | -            |
| 30, . .             | 0.95    | 0.23     | 0.45       | 2.58        | 0.63           | 0.87      | 1.36   | 0.46     | 1.38         | 30, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 31, . .             | -       | -        | 0.01       | -           | -              | -         | -      | -        | -            | 31, . .             | 0.90    | -        | 0.44       | 0.75        | 0.72           | 0.24      | 0.59   | 0.70     | -            |
| TOTALS,             | 6.35    | 3.88     | 6.26       | 5.17        | 3.55           | 3.21      | 3.76   | 3.56     | 4.84         | TOTALS,             | 2.90    | 2.74     | 2.09       | 4.00        | 3.91           | 2.49      | 4.96   | 3.77     | 2.51         |

\* Precipitation included in that of following day.

*Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected*  
— Continued.

| September, 1895.    |         |          |            |             |                |           |        |          | October, 1895. |                     |         |          |            |             |                |           |        |          |              |
|---------------------|---------|----------|------------|-------------|----------------|-----------|--------|----------|----------------|---------------------|---------|----------|------------|-------------|----------------|-----------|--------|----------|--------------|
| DAY<br>OF<br>MONTH. | Ludlow. | Amherst. | Fitchburg. | Framingham. | Chestnut Hill. | Lawrence. | Salem. | Taunton. | New Bedford.   | DAY<br>OF<br>MONTH. | Ludlow. | Amherst. | Fitchburg. | Framingham. | Chestnut Hill. | Lawrence. | Salem. | Taunton. | New Bedford. |
| 1, . .              | -       | -        | -          | -           | -              | -         | -      | -        | 0.25           | 1, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 2, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -              | 2, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 3, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -              | 3, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 4, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -              | 4, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 5, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -              | 5, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 6, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -              | 6, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 7, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -              | 7, . .              | -       | *        | 0.11       | 0.02        | -              | -         | -      | -        | 0.02         |
| 8, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -              | 8, . .              | 0.05    | 0.33     | -          | 0.16        | 0.31           | 0.17      | 0.18   | 0.25     | 0.29         |
| 9, . .              | *       | 0.78     | 0.31       | -           | -              | 0.24      | *      | -        | -              | 9, . .              | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 10, . .             | 0.70    | -        | -          | 0.55        | 0.52           | -         | 0.27   | 0.56     | 0.23           | 10, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 11, . .             | 0.60    | 1.25     | 0.37       | 0.14        | 0.75           | 0.21      | 0.39   | 0.06     | 0.03           | 11, . .             | 0.30    | -        | -          | -           | -              | -         | -      | -        | -            |
| 12, . .             | 0.50    | 0.18     | 0.47       | 0.50        | 0.29           | 0.46      | 0.39   | 0.17     | 0.18           | 12, . .             | *       | *        | -          | *           | *              | *         | *      | *        | *            |
| 13, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -              | 13, . .             | 4.25    | *        | 1.81       | *           | *              | *         | *      | *        | 3.18         |
| 14, . .             | -       | -        | -          | -           | -              | 0.04      | -      | -        | -              | 14, . .             | -       | 2.57     | 3.00       | 8.49        | 7.55           | 4.82      | 5.27   | 5.09     | 0.20         |
| 15, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -              | 15, . .             | -       | *        | 0.41       | 0.03        | 0.05           | 0.05      | 0.05   | -        | *            |
| 16, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -              | 16, . .             | -       | 0.11     | -          | -           | -              | -         | -      | -        | 0.02         |
| 17, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -              | 17, . .             | -       | -        | 0.10       | -           | -              | -         | -      | -        | -            |
| 18, . .             | 0.20    | 0.39     | 0.12       | 0.10        | 0.10           | 0.03      | *      | 0.17     | 0.08           | 18, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 19, . .             | -       | -        | 0.03       | -           | -              | -         | 0.09   | -        | -              | 19, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 20, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -              | 20, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 21, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -              | 21, . .             | -       | -        | -          | -           | -              | -         | -      | -        | 0.03         |
| 22, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -              | 22, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 23, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -              | 23, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 24, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -              | 24, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 25, . .             | -       | 0.45     | 0.54       | -           | -              | -         | -      | -        | -              | 25, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 26, . .             | -       | -        | -          | 0.33        | 0.05           | 0.49      | 0.08   | *        | 0.79           | 26, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 27, . .             | -       | -        | -          | -           | 0.15           | 0.04      | 0.13   | 1.03     | -              | 27, . .             | -       | 0.57     | -          | -           | -              | -         | -      | -        | -            |
| 28, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -              | 28, . .             | 0.30    | -        | 0.28       | 0.06        | 0.03           | 0.06      | 0.03   | -        | -            |
| 29, . .             | -       | *        | -          | -           | -              | -         | -      | -        | -              | 29, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 30, . .             | 1.75    | 1.56     | 0.86       | 0.57        | 0.29           | 0.47      | 0.06   | 0.14     | 0.70           | 30, . .             | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| TOTALS,             | 3.75    | 4.64     | 2.70       | 2.19        | 2.15           | 1.98      | 1.41   | 2.13     | 2.26           | TOTALS,             | 6.65    | 4.95     | 7.10       | 9.01        | 9.24           | 6.10      | 7.17   | 8.61     | 4.04         |

\* Precipitation included in that of following day.

*Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected*  
— Concluded.

| November, 1895.     |         |          |            |             |                |           |        |          |              | December, 1895.     |         |          |            |             |                |           |        |          |              |
|---------------------|---------|----------|------------|-------------|----------------|-----------|--------|----------|--------------|---------------------|---------|----------|------------|-------------|----------------|-----------|--------|----------|--------------|
| DAY<br>OF<br>MONTH. | Ludlow. | Amherst. | Fitchburg. | Framingham. | Chestnut Hill. | Lawrence. | Salem. | Taunton. | New Bedford. | DAY<br>OF<br>MONTH. | Ludlow. | Amherst. | Fitchburg. | Framingham. | Chestnut Hill. | Lawrence. | Salem. | Taunton. | New Bedford. |
| 1, . . .            | -       | -        | 1.41       | 2.22        | 1.56           | 1.01      | 1.93   | 0.92     | 1.24         | 1, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 2, . . .            | 0.54    | *        | 0.48       | *           | *              | *         | *      | 0.88     | *            | 2, . . .            | 0.48    | 0.72     | 0.48       | 0.30        | 0.16           | 0.20      | -      | 0.42     | *            |
| 3, . . .            | -       | 0.64     | -          | 0.53        | 0.62           | 0.43      | 0.58   | -        | 0.85         | 3, . . .            | -       | -        | -          | -           | -              | 0.07      | -      | 0.50     | -            |
| 4, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            | 4, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 5, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            | 5, . . .            | 0.32    | 0.52     | 0.68       | *           | *              | *         | *      | *        | 0.08         |
| 6, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            | 6, . . .            | -       | -        | 0.16       | 0.96        | 0.56           | 0.63      | 0.73   | 0.63     | 0.36         |
| 7, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            | 7, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 8, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            | 8, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 9, . . .            | -       | *        | 0.11       | *           | *              | *         | *      | *        | -            | 9, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | 0.03         |
| 10, . . .           | 0.25    | 0.33     | 0.08       | 0.16        | 0.15           | 0.13      | 0.16   | 0.05     | 0.07         | 10, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 11, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 11, . . .           | -       | -        | -          | -           | -              | -         | -      | *        | *            |
| 12, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 12, . . .           | -       | -        | -          | -           | -              | -         | -      | *        | 0.05         |
| 13, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 13, . . .           | -       | -        | -          | 0.02        | -              | 0.09      | *      | 0.03     | -            |
| 14, . . .           | 1.50    | *        | 0.15       | *           | *              | -         | *      | *        | *            | 14, . . .           | -       | -        | -          | -           | -              | -         | -      | 0.30     | -            |
| 15, . . .           | 0.45    | 1.91     | 1.66       | 2.46        | 1.93           | 1.86      | 2.86   | 0.50     | 0.70         | 15, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 16, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 16, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 17, . . .           | 0.55    | 0.39     | 0.59       | 0.93        | 0.81           | 0.92      | *      | 0.72     | *            | 17, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 18, . . .           | -       | -        | -          | -           | -              | -         | 0.73   | -        | 0.80         | 18, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 19, . . .           | -       | -        | -          | -           | -              | *         | -      | -        | -            | 19, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 20, . . .           | 0.48    | 0.30     | 0.22       | 0.06        | 0.68           | 0.48      | 0.70   | 0.85     | 0.35         | 20, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 21, . . .           | -       | -        | -          | 0.37        | 0.39           | -         | 0.34   | 0.49     | 0.47         | 21, . . .           | -       | 0.60     | -          | 0.83        | -              | -         | -      | -        | -            |
| 22, . . .           | -       | -        | -          | -           | -              | *         | -      | -        | -            | 22, . . .           | 1.30    | -        | 0.73       | -           | 0.60           | 0.71      | 0.73   | 0.92     | 0.71         |
| 23, . . .           | -       | -        | 0.05       | *           | *              | *         | 0.01   | -        | -            | 23, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 24, . . .           | 0.20    | *        | 0.20       | 0.22        | 0.18           | 0.36      | 0.16   | 0.14     | 0.09         | 24, . . .           | -       | -        | -          | -           | -              | 0.02      | -      | 0.03     | -            |
| 25, . . .           | *       | *        | 0.20       | *           | *              | *         | *      | 0.04     | 0.01         | 25, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 26, . . .           | 0.34    | 1.27     | 0.51       | 2.05        | 0.12           | 0.27      | 0.14   | -        | *            | 26, . . .           | -       | *        | 0.03       | *           | -              | *         | -      | -        | -            |
| 27, . . .           | 0.75    | -        | 0.22       | -           | 1.25           | 1.40      | 0.99   | 1.14     | 0.41         | 27, . . .           | 0.33    | 0.28     | 0.44       | 0.36        | 0.34           | 0.38      | 0.31   | 0.23     | 0.30         |
| 28, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 28, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 29, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 29, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 30, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 30, . . .           | *       | -        | 0.16       | *           | *              | *         | *      | *        | *            |
| TOTALS,             | 5.06    | 4.84     | 5.88       | 9.00        | 7.69           | 6.86      | 8.60   | 5.73     | 4.99         | TOTALS,             | 1.40    | 1.42     | 1.11       | 0.73        | 0.67           | 0.49      | 0.70   | 0.97     | 0.54         |

\* Precipitation included in that of following day.



## FLOW OF STREAMS.

The flow of the -streams of the State during the year 1895, as indicated by the flow of the Sudbury River, was a very little greater than the average for the past twenty-one years. In order to show the relation between the flow of the Sudbury River during each month in 1895 and the normal flow of the same river, as deduced from observations for twenty-one years from 1875 to 1895, inclusive, the following table has been prepared.

The area of the watershed of the Sudbury River above the point where its flow is measured is 75.2 square miles.

*Table showing Average Monthly Flow of Sudbury River for the Year 1895, in Cubic Feet per Second per Square Mile of Drainage Area, also Departures from the Normal Flow.*

| MONTH.               | NORMAL FLOW.                                 | ACTUAL FLOW                                              | EXCESS OR DE-                                             |
|----------------------|----------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------|
|                      | Cubic Feet per<br>Second per<br>Square Mile. | IN 1895.<br>Cubic Feet per<br>Second per<br>Square Mile. | FICIENCY.<br>Cubic Feet per<br>Second per<br>Square Mile. |
| January, . . . . .   | 1.874                                        | 1.599                                                    | -0.275                                                    |
| February, . . . . .  | 2.355                                        | 0.836                                                    | -2.019                                                    |
| March, . . . . .     | 4.371                                        | 3.727                                                    | -0.644                                                    |
| April, . . . . .     | 3.177                                        | 3.890                                                    | +0.713                                                    |
| May, . . . . .       | 1.776                                        | 0.983                                                    | -0.793                                                    |
| June, . . . . .      | 0.731                                        | 0.270                                                    | -0.461                                                    |
| July, . . . . .      | 0.290                                        | 0.356                                                    | +0.066                                                    |
| August, . . . . .    | 0.442                                        | 0.355                                                    | -0.087                                                    |
| September, . . . . . | 0.370                                        | 0.137                                                    | -0.233                                                    |
| October, . . . . .   | 0.843                                        | 2.133                                                    | +1.290                                                    |
| November, . . . . .  | 1.471                                        | 4.295                                                    | +2.824                                                    |
| December, . . . . .  | 1.605                                        | 2.756                                                    | +1.151                                                    |
| AVERAGE, . . . . .   | 1.644                                        | 1.791                                                    | +0.147                                                    |

The next table shows the weekly fluctuations, during 1895, in the flow of the two streams most carefully measured, namely, the Sudbury and the Merrimack. The flow of these streams, particularly the Sudbury, will serve to indicate the condition of other streams in eastern Massachusetts.

| WEEK ENDING SUNDAY. | SUDBURY RIVER.<br>Cubic Feet<br>per<br>Second<br>per Square<br>Mile. | MERRIMACK RIVER.<br>Cubic Feet<br>per<br>Second<br>per Square<br>Mile. | WEEK ENDING SUNDAY. | SUDBURY RIVER.<br>Cubic Feet<br>per<br>Second<br>per Square<br>Mile. | MERRIMACK RIVER.<br>Cubic Feet<br>per<br>Second<br>per Square<br>Mile. |
|---------------------|----------------------------------------------------------------------|------------------------------------------------------------------------|---------------------|----------------------------------------------------------------------|------------------------------------------------------------------------|
| Jan. 6, . . . . .   | 0.346                                                                | 0.493                                                                  | July 7, . . . . .   | 0.190                                                                | 0.613                                                                  |
| 13, . . . . .       | 1.214                                                                | 0.537                                                                  | 14, . . . . .       | 0.187                                                                | 0.614                                                                  |
| 20, . . . . .       | 1.138                                                                | 0.760                                                                  | 21, . . . . .       | 0.120                                                                | 0.542                                                                  |
| 27, . . . . .       | 0.999                                                                | 0.657                                                                  | 28, . . . . .       | 0.088                                                                | 0.453                                                                  |
| Feb. 3, . . . . .   | 0.802                                                                | 0.607                                                                  | Aug. 4, . . . . .   | 0.476                                                                | 0.496                                                                  |
| 10, . . . . .       | 0.600                                                                | 0.517                                                                  | 11, . . . . .       | 0.290                                                                | 0.473                                                                  |
| 17, . . . . .       | 0.486                                                                | 0.482                                                                  | 18, . . . . .       | 0.208                                                                | 0.449                                                                  |
| 24, . . . . .       | 0.446                                                                | 0.498                                                                  | 25, . . . . .       | 0.360                                                                | 0.505                                                                  |
| Mar. 3, . . . . .   | 0.653                                                                | 0.491                                                                  | Sept. 1, . . . . .  | 0.139                                                                | 0.411                                                                  |
| 10, . . . . .       | 1.483                                                                | 0.709                                                                  | 8, . . . . .        | 0.036                                                                | 0.337                                                                  |
| 17, . . . . .       | 3.523                                                                | 1.392                                                                  | 15, . . . . .       | 0.145                                                                | 0.392                                                                  |
| 24, . . . . .       | 2.072                                                                | 1.419                                                                  | 22, . . . . .       | 0.878                                                                | 0.374                                                                  |
| 31, . . . . .       | 2.302                                                                | 1.902                                                                  | 29, . . . . .       | 0.025                                                                | 0.333                                                                  |
| Apr. 7, . . . . .   | 1.726                                                                | 1.594                                                                  | Oct. 6, . . . . .   | 0.804                                                                | 0.432                                                                  |
| 14, . . . . .       | 2.507                                                                | 4.975                                                                  | 13, . . . . .       | 0.333                                                                | 0.416                                                                  |
| 21, . . . . .       | 4.165                                                                | 8.098                                                                  | 20, . . . . .       | 3.757                                                                | 1.771                                                                  |
| 28, . . . . .       | 1.432                                                                | 3.050                                                                  | 27, . . . . .       | 0.777                                                                | 0.843                                                                  |
| May 5, . . . . .    | 0.988                                                                | 2.020                                                                  | Nov. 3, . . . . .   | 1.437                                                                | 0.996                                                                  |
| 12, . . . . .       | 0.619                                                                | 1.569                                                                  | 10, . . . . .       | 1.636                                                                | 1.321                                                                  |
| 19, . . . . .       | 0.694                                                                | 1.335                                                                  | 17, . . . . .       | 2.137                                                                | 1.826                                                                  |
| 26, . . . . .       | 0.426                                                                | 0.870                                                                  | 24, . . . . .       | 3.226                                                                | 2.523                                                                  |
| June 2, . . . . .   | 0.407                                                                | 1.064                                                                  | Dec. 1, . . . . .   | 3.367                                                                | 2.933                                                                  |
| 9, . . . . .        | 0.307                                                                | 0.826                                                                  | 8, . . . . .        | 2.081                                                                | 2.240                                                                  |
| 16, . . . . .       | 0.240                                                                | 0.629                                                                  | 15, . . . . .       | 1.179                                                                | 1.596                                                                  |
| 23, . . . . .       | -0.277                                                               | 0.499                                                                  | 22, . . . . .       | 1.282                                                                | 1.182                                                                  |
| 30, . . . . .       | 0.318                                                                | 0.603                                                                  | 29, . . . . .       | 2.016                                                                | 2.903                                                                  |

In the annual report of the State Board of Health for the year 1890 (pages 338 to 340) a table, taken from the annual reports of the Boston Water Board, was printed, giving the records of rainfall upon the Sudbury River watershed and its yield, expressed in inches in depth on the watershed (inches of rainfall collected), for sixteen years, from 1875 to 1890, inclusive. The corresponding records for the years 1891 and 1892 were given in the annual report for 1892, and the records for the years 1893 and 1894 in the annual reports for those years. For convenience, the records from 1891 to 1894, inclusive, are reprinted in the following table, together with the record for 1895 and an average for the whole twenty-one years : —

## FLOW OF STREAMS.

The flow of the streams of the State during the year 1895, as indicated by the flow of the Sudbury River, was a very little greater than the average for the past twenty-one years. In order to show the relation between the flow of the Sudbury River during each month in 1895 and the normal flow of the same river, as deduced from observations for twenty-one years from 1875 to 1895, inclusive, the following table has been prepared.

The area of the watershed of the Sudbury River above the point where its flow is measured is 75.2 square miles.

*Table showing Average Monthly Flow of Sudbury River for the Year 1895, in Cubic Feet per Second per Square Mile of Drainage Area, also Departures from the Normal Flow.*

| MONTH.               | NORMAL FLOW.                                 | ACTUAL FLOW                                              | EXCESS OR DE-                                             |
|----------------------|----------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------|
|                      | Cubic Feet per<br>Second per<br>Square Mile. | IN 1895.<br>Cubic Feet per<br>Second per<br>Square Mile. | FICIENCY.<br>Cubic Feet per<br>Second per<br>Square Mile. |
| January, . . . . .   | 1.874                                        | 1.599                                                    | -0.275                                                    |
| February, . . . . .  | 2.855                                        | 0.836                                                    | -2.019                                                    |
| March, . . . . .     | 4.871                                        | 3.727                                                    | -0.644                                                    |
| April, . . . . .     | 3.177                                        | 3.890                                                    | +0.713                                                    |
| May, . . . . .       | 1.776                                        | 0.983                                                    | -0.793                                                    |
| June, . . . . .      | 0.781                                        | 0.270                                                    | -0.461                                                    |
| July, . . . . .      | 0.290                                        | 0.356                                                    | +0.066                                                    |
| August, . . . . .    | 0.442                                        | 0.355                                                    | -0.087                                                    |
| September, . . . . . | 0.370                                        | 0.137                                                    | -0.233                                                    |
| October, . . . . .   | 0.843                                        | 2.133                                                    | +1.290                                                    |
| November, . . . . .  | 1.471                                        | 4.295                                                    | +2.824                                                    |
| December, . . . . .  | 1.605                                        | 2.756                                                    | +1.151                                                    |
| ANNUAL . . . . .     | 1.644                                        | 1.791                                                    | +0.147                                                    |

shows the weekly fluctuations, during 1895, in the streams most carefully measured, namely, the Sudbury and Merrimack. The flow of these streams, particularly the Merrimack, will serve to indicate the condition of other streams in Massachusetts.

| WEEK ENDING SUNDAY. | SUDBURY RIVER.<br>Cubic Feet<br>per<br>Second<br>per Square<br>Mile. | MERRIMACK RIVER.<br>Cubic Feet<br>per<br>Second<br>per Square<br>Mile. | WEEK ENDING SUNDAY. | SUDBURY RIVER.<br>Cubic Feet<br>per<br>Second<br>per Square<br>Mile. | MERRIMACK RIVER.<br>Cubic Feet<br>per<br>Second<br>per Square<br>Mile. |
|---------------------|----------------------------------------------------------------------|------------------------------------------------------------------------|---------------------|----------------------------------------------------------------------|------------------------------------------------------------------------|
| Jan. 6, . . . .     | 0.346                                                                | 0.493                                                                  | July 7, . . . .     | 0.190                                                                | 0.613                                                                  |
| 18, . . . .         | 1.214                                                                | 0.537                                                                  | 14, . . . .         | 0.187                                                                | 0.614                                                                  |
| 20, . . . .         | 1.138                                                                | 0.760                                                                  | 21, . . . .         | 0.120                                                                | 0.542                                                                  |
| 27, . . . .         | 0.999                                                                | 0.657                                                                  | 28, . . . .         | 0.088                                                                | 0.453                                                                  |
| Feb. 3, . . . .     | 0.802                                                                | 0.607                                                                  | Aug. 4, . . . .     | 0.476                                                                | 0.496                                                                  |
| 10, . . . .         | 0.600                                                                | 0.517                                                                  | 11, . . . .         | 0.290                                                                | 0.473                                                                  |
| 17, . . . .         | 0.486                                                                | 0.482                                                                  | 18, . . . .         | 0.208                                                                | 0.449                                                                  |
| 24, . . . .         | 0.446                                                                | 0.493                                                                  | 25, . . . .         | 0.360                                                                | 0.505                                                                  |
| Mar. 3, . . . .     | 0.653                                                                | 0.491                                                                  | Sept. 1, . . . .    | 0.139                                                                | 0.411                                                                  |
| 10, . . . .         | 1.483                                                                | 0.709                                                                  | 8, . . . .          | 0.036                                                                | 0.387                                                                  |
| 17, . . . .         | 3.523                                                                | 1.392                                                                  | 15, . . . .         | 0.145                                                                | 0.392                                                                  |
| 24, . . . .         | 2.072                                                                | 1.419                                                                  | 22, . . . .         | 0.878                                                                | 0.374                                                                  |
| 31, . . . .         | 2.302                                                                | 1.902                                                                  | 29, . . . .         | 0.025                                                                | 0.333                                                                  |
| Apr. 7, . . . .     | 1.726                                                                | 1.594                                                                  | Oct. 6, . . . .     | 0.804                                                                | 0.432                                                                  |
| 14, . . . .         | 2.507                                                                | 4.975                                                                  | 13, . . . .         | 0.333                                                                | 0.416                                                                  |
| 21, . . . .         | 4.165                                                                | 8.093                                                                  | 20, . . . .         | 3.757                                                                | 1.771                                                                  |
| 28, . . . .         | 1.432                                                                | 3.050                                                                  | 27, . . . .         | 0.777                                                                | 0.843                                                                  |
| May 5, . . . .      | 0.988                                                                | 2.020                                                                  | Nov. 3, . . . .     | 1.427                                                                | 0.986                                                                  |
| 12, . . . .         | 0.619                                                                | 1.569                                                                  | 10, . . . .         | 1.636                                                                | 1.321                                                                  |
| 19, . . . .         | 0.694                                                                | 1.335                                                                  | 17, . . . .         | 2.137                                                                | 1.826                                                                  |
| 26, . . . .         | 0.426                                                                | 0.870                                                                  | 24, . . . .         | 3.226                                                                | 2.523                                                                  |
| June 2, . . . .     | 0.407                                                                | 1.064                                                                  | Dec. 1, . . . .     | 3.367                                                                | 2.933                                                                  |
| 9, . . . .          | 0.307                                                                | 0.826                                                                  | 8, . . . .          | 2.081                                                                | 2.240                                                                  |
| 16, . . . .         | 0.240                                                                | 0.629                                                                  | 15, . . . .         | 1.179                                                                | 1.596                                                                  |
| 23, . . . .         | -0.277                                                               | 0.499                                                                  | 22, . . . .         | 1.282                                                                | 1.182                                                                  |
| 30, . . . .         | 0.318                                                                | 0.603                                                                  | 29, . . . .         | 2.016                                                                | 2.903                                                                  |

In the annual report of the State Board of Health for the year 1890 (pages 338 to 340) a table, taken from the annual reports of the Boston Water Board, was printed, giving the records of rainfall upon the Sudbury River watershed and its yield, expressed in inches in depth on the watershed (inches of rainfall collected), for sixteen years, from 1875 to 1890, inclusive. The corresponding records for the years 1891 and 1892 were given in the annual report for 1892, and the records for the years 1893 and 1894 in the annual reports for those years. For convenience, the records from 1891 to 1894, inclusive, are reprinted in the following table, together with the record for 1895 and an average for the whole twenty-one years : —

## FLOW OF STREAMS.

The flow of the streams of the State during the year 1895, as indicated by the flow of the Sudbury River, was a very little greater than the average for the past twenty-one years. In order to show the relation between the flow of the Sudbury River during each month in 1895 and the normal flow of the same river, as deduced from observations for twenty-one years from 1875 to 1895, inclusive, the following table has been prepared.

The area of the watershed of the Sudbury River above the point where its flow is measured is 75.2 square miles.

*Table showing Average Monthly Flow of Sudbury River for the Year 1895, in Cubic Feet per Second per Square Mile of Drainage Area, also Departures from the Normal Flow.*

| MONTH.               | NORMAL FLOW.<br>Cubic Feet per<br>Second per<br>Square Mile. | ACTUAL FLOW<br>IN 1895.<br>Cubic Feet per<br>Second per<br>Square Mile. | EXCESS OR DE-<br>FICIENCY.<br>Cubic Feet per<br>Second per<br>Square Mile. |
|----------------------|--------------------------------------------------------------|-------------------------------------------------------------------------|----------------------------------------------------------------------------|
| January, . . . . .   | 1.874                                                        | 1.599                                                                   | -0.275                                                                     |
| February, . . . . .  | 2.855                                                        | 0.836                                                                   | -2.019                                                                     |
| March, . . . . .     | 4.871                                                        | 3.727                                                                   | -0.644                                                                     |
| April, . . . . .     | 3.177                                                        | 3.890                                                                   | +0.713                                                                     |
| May, . . . . .       | 1.770                                                        | 0.983                                                                   | -0.793                                                                     |
| June, . . . . .      | 0.731                                                        | 0.270                                                                   | -0.461                                                                     |
| July, . . . . .      | 0.290                                                        | 0.356                                                                   | +0.066                                                                     |
| August, . . . . .    | 0.442                                                        | 0.355                                                                   | -0.087                                                                     |
| September, . . . . . | 0.370                                                        | 0.137                                                                   | -0.233                                                                     |
| October, . . . . .   | 0.843                                                        | 2.133                                                                   | +1.290                                                                     |
| November, . . . . .  | 1.471                                                        | 4.295                                                                   | +2.824                                                                     |
| December, . . . . .  | 1.005                                                        | 2.756                                                                   | +1.151                                                                     |
| AVERAGE, . . . . .   | 1.644                                                        | 1.791                                                                   | +0.147                                                                     |

The next table shows the weekly fluctuations, during 1895, in the flow of the two streams most carefully measured, namely, the Sudbury and the Merrimack. The flow of these streams, particularly the Sudbury, will serve to indicate the condition of other streams in eastern Massachusetts.

| WEEK ENDING SUNDAY. | SUDBURY RIVER.<br>Cubic Feet<br>per<br>Second<br>per Square<br>Mile. | MERRIMACK RIVER.<br>Cubic Feet<br>per<br>Second<br>per Square<br>Mile. | WEEK ENDING SUNDAY. | SUDBURY RIVER.<br>Cubic Feet<br>per<br>Second<br>per Square<br>Mile. | MERRIMACK RIVER.<br>Cubic Feet<br>per<br>Second<br>per Square<br>Mile. |
|---------------------|----------------------------------------------------------------------|------------------------------------------------------------------------|---------------------|----------------------------------------------------------------------|------------------------------------------------------------------------|
| Jan. 6, . . . .     | 0.346                                                                | 0.403                                                                  | July 7, . . . .     | 0.190                                                                | 0.613                                                                  |
| 13, . . . .         | 1.214                                                                | 0.537                                                                  | 14, . . . .         | 0.187                                                                | 0.614                                                                  |
| 20, . . . .         | 1.138                                                                | 0.700                                                                  | 21, . . . .         | 0.120                                                                | 0.542                                                                  |
| 27, . . . .         | 0.999                                                                | 0.657                                                                  | 28, . . . .         | 0.088                                                                | 0.453                                                                  |
| Feb. 3, . . . .     | 0.802                                                                | 0.607                                                                  | Aug. 4, . . . .     | 0.476                                                                | 0.496                                                                  |
| 10, . . . .         | 0.600                                                                | 0.517                                                                  | 11, . . . .         | 0.290                                                                | 0.473                                                                  |
| 17, . . . .         | 0.486                                                                | 0.482                                                                  | 18, . . . .         | 0.208                                                                | 0.449                                                                  |
| 24, . . . .         | 0.446                                                                | 0.408                                                                  | 25, . . . .         | 0.360                                                                | 0.505                                                                  |
| Mar. 3, . . . .     | 0.683                                                                | 0.491                                                                  | Sept. 1, . . . .    | 0.139                                                                | 0.411                                                                  |
| 10, . . . .         | 1.483                                                                | 0.709                                                                  | 8, . . . .          | 0.036                                                                | 0.387                                                                  |
| 17, . . . .         | 3.523                                                                | 1.392                                                                  | 15, . . . .         | 0.145                                                                | 0.392                                                                  |
| 24, . . . .         | 2.072                                                                | 1.419                                                                  | 22, . . . .         | 0.878                                                                | 0.374                                                                  |
| 31, . . . .         | 2.302                                                                | 1.902                                                                  | 29, . . . .         | 0.025                                                                | 0.333                                                                  |
| Apr. 7, . . . .     | 1.726                                                                | 1.594                                                                  | Oct. 6, . . . .     | 0.804                                                                | 0.432                                                                  |
| 14, . . . .         | 2.507                                                                | 4.975                                                                  | 13, . . . .         | 0.333                                                                | 0.416                                                                  |
| 21, . . . .         | 4.165                                                                | 8.093                                                                  | 20, . . . .         | 3.757                                                                | 1.771                                                                  |
| 28, . . . .         | 1.432                                                                | 3.050                                                                  | 27, . . . .         | 0.777                                                                | 0.843                                                                  |
| May 5, . . . .      | 0.988                                                                | 2.020                                                                  | Nov. 3, . . . .     | 1.427                                                                | 0.986                                                                  |
| 12, . . . .         | 0.619                                                                | 1.569                                                                  | 10, . . . .         | 1.636                                                                | 1.321                                                                  |
| 19, . . . .         | 0.694                                                                | 1.335                                                                  | 17, . . . .         | 2.137                                                                | 1.826                                                                  |
| 26, . . . .         | 0.426                                                                | 0.870                                                                  | 24, . . . .         | 3.226                                                                | 2.523                                                                  |
| June 2, . . . .     | 0.407                                                                | 1.084                                                                  | Dec. 1, . . . .     | 3.367                                                                | 2.933                                                                  |
| 9, . . . .          | 0.307                                                                | 0.826                                                                  | 8, . . . .          | 2.081                                                                | 2.240                                                                  |
| 16, . . . .         | 0.240                                                                | 0.629                                                                  | 15, . . . .         | 1.179                                                                | 1.596                                                                  |
| 23, . . . .         | -0.277                                                               | 0.499                                                                  | 22, . . . .         | 1.282                                                                | 1.182                                                                  |
| 30, . . . .         | 0.318                                                                | 0.603                                                                  | 29, . . . .         | 2.016                                                                | 2.903                                                                  |

In the annual report of the State Board of Health for the year 1890 (pages 338 to 340) a table, taken from the annual reports of the Boston Water Board, was printed, giving the records of rainfall upon the Sudbury River watershed and its yield, expressed in inches in depth on the watershed (inches of rainfall collected), for sixteen years, from 1875 to 1890, inclusive. The corresponding records for the years 1891 and 1892 were given in the annual report for 1892, and the records for the years 1893 and 1894 in the annual reports for those years. For convenience, the records from 1891 to 1894, inclusive, are reprinted in the following table, together with the record for 1895 and an average for the whole twenty-one years:—

*Rainfall Received and Collected on the Sudbury River Watershed.*

| MONTH.                         | 1891.     |                     |                     | 1892.     |                     |                     | 1893.     |                     |                     | 1894.     |                     |                     | 1895.     |                     |                     | MEAN FOR 21 YEARS,<br>1873-1893. |                     |                     |
|--------------------------------|-----------|---------------------|---------------------|-----------|---------------------|---------------------|-----------|---------------------|---------------------|-----------|---------------------|---------------------|-----------|---------------------|---------------------|----------------------------------|---------------------|---------------------|
|                                | Rainfall. | Rainfall Collected. | Per Cent Collected. | Rainfall. | Rainfall Collected. | Per Cent Collected. | Rainfall. | Rainfall Collected. | Per Cent Collected. | Rainfall. | Rainfall Collected. | Per Cent Collected. | Rainfall. | Rainfall Collected. | Per Cent Collected. | Rainfall.                        | Rainfall Collected. | Per Cent Collected. |
|                                | Inches.   | Inches.             |                     | Inches.   | Inches.             |                     | Inches.   | Inches.             |                     | Inches.   | Inches.             |                     | Inches.   | Inches.             |                     | Inches.                          | Inches.             |                     |
| January, . . . . .             | 7.020     | 5.883               | 76.69               | 5.850     | 3.335               | 57.01               | 2.925     | 0.773               | 26.44               | 4.090     | 1.236               | 30.22               | 4.090     | 1.844               | 45.4                | 4.325                            | 2.161               | 48.4                |
| February, . . . . .            | 5.235     | 5.618               | 107.28              | 3.140     | 1.574               | 50.13               | 8.195     | 2.465               | 30.32               | 3.910     | 1.596               | 40.82               | 1.395     | 0.871               | 62.5                | 4.136                            | 2.998               | 78.6                |
| March, . . . . .               | 6.475     | 7.944               | 122.69              | 4.060     | 3.498               | 85.90               | 3.670     | 5.799               | 157.74              | 1.435     | 3.992               | 278.19              | 2.980     | 4.290               | 144.2               | 4.876                            | 5.039               | 130.1               |
| April, . . . . .               | 3.905     | 4.138               | 105.97              | 0.830     | 1.504               | 181.15              | 3.605     | 3.698               | 101.75              | 3.415     | 2.832               | 82.93               | 5.250     | 4.341               | 82.7                | 3.330                            | 3.545               | 113.3               |
| May, . . . . .                 | 2.010     | 1.030               | 51.70               | 5.585     | 2.245               | 40.20               | 6.610     | 5.143               | 77.81               | 4.235     | 1.498               | 35.37               | 2.020     | 1.134               | 56.1                | 3.415                            | 2.048               | 71.9                |
| June, . . . . .                | 3.770     | 0.714               | 18.92               | 2.760     | 0.739               | 26.76               | 2.350     | 0.759               | 31.88               | 1.155     | 0.723               | 62.60               | 2.770     | 0.801               | 10.8                | 2.895                            | 0.816               | 29.8                |
| July, . . . . .                | 3.395     | 0.296               | 7.83                | 4.230     | 0.392               | 9.03                | 2.570     | 0.292               | 10.96               | 3.255     | 0.287               | 8.82                | 5.040     | 0.411               | 8.2                 | 3.764                            | 0.334               | 9.5                 |
| August, . . . . .              | 4.725     | 0.290               | 6.15                | 4.440     | 0.500               | 11.26               | 5.415     | 0.322               | 5.95                | 2.030     | 0.373               | 18.37               | 4.150     | 0.409               | 9.9                 | 4.209                            | 0.510               | 13.8                |
| September, . . . . .           | 2.380     | 0.350               | 14.71               | 2.840     | 0.396               | 13.94               | 1.735     | 0.187               | 10.75               | 2.635     | 0.258               | 9.79                | 2.300     | 0.153               | 6.7                 | 3.029                            | 0.414               | 13.8                |
| October, . . . . .             | 3.830     | 0.375               | 9.78                | 1.170     | 0.224               | 19.18               | 4.065     | 0.395               | 9.72                | 5.345     | 0.698               | 12.50               | 10.680    | 2.460               | 23.0                | 4.557                            | 0.971               | 19.4                |
| November, . . . . .            | 3.090     | 0.526               | 17.03               | 5.800     | 1.204               | 20.75               | 2.195     | 0.550               | 25.07               | 3.425     | 1.442               | 42.10               | 6.625     | 4.794               | 72.4                | 4.135                            | 1.641               | 39.4                |
| December, . . . . .            | 3.695     | 0.971               | 26.34               | 1.125     | 0.865               | 76.89               | 4.860     | 1.421               | 29.23               | 4.810     | 1.277               | 26.55               | 3.350     | 3.179               | 94.9                | 3.676                            | 1.851               | 60.8                |
| Totals and averages, . . . . . | 49.520    | 27.612              | 55.76               | 41.830    | 16.456              | 39.34               | 48.225    | 21.774              | 45.15               | 39.740    | 16.182              | 40.72               | 50.620    | 24.196              | 47.8                | 45.845                           | 22.328              | 48.0                |

The Sudbury River records are particularly valuable as a basis for estimating the yield of other watersheds in Massachusetts, both on account of the accuracy with which the measurements have been made during the whole twenty years, and the absence of abnormal conditions which would unfavorably affect the results. It is therefore thought advisable to publish in the following table those portions of the records relating to the yield of this watershed for each of the twenty years; and in doing so the flow from the watershed is expressed in gallons per day per square mile, instead of inches in depth of rainfall collected, in order to render the table more convenient for use in estimating the probable yield of watersheds used as sources of water supply.

*Yield of the Sudbury River Watershed in Gallons per Day per Square Mile.\**

| MONTH.                     | 1875.     | 1876.     | 1877.     | 1878.     | 1879.     | 1880.     | 1881.     | 1882.     |
|----------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| January, . . . . .         | 103,000   | 643,000   | 658,000   | 1,810,000 | 700,000   | 1,121,000 | 415,000   | 1,241,000 |
| February, . . . . .        | 1,496,000 | 1,368,000 | 940,000   | 2,465,000 | 1,711,000 | 1,787,000 | 1,546,000 | 2,403,000 |
| March, . . . . .           | 1,604,000 | 4,435,000 | 4,813,000 | 3,507,000 | 2,330,000 | 1,374,000 | 4,004,000 | 2,830,000 |
| April, . . . . .           | 3,049,000 | 3,292,000 | 2,394,000 | 1,626,000 | 3,116,000 | 1,188,000 | 1,546,000 | 867,000   |
| May, . . . . .             | 1,188,000 | 1,139,000 | 1,391,000 | 1,394,000 | 1,114,000 | 514,000   | 965,000   | 1,292,000 |
| June, . . . . .            | 870,000   | 222,000   | 597,000   | 506,000   | 413,000   | 176,000   | 1,338,000 | 529,000   |
| July, . . . . .            | 321,000   | 183,000   | 202,000   | 128,000   | 158,000   | 177,000   | 276,000   | 86,000    |
| August, . . . . .          | 396,000   | 405,000   | 121,000   | 475,000   | 895,000   | 119,000   | 148,000   | 55,000    |
| September, . . . . .       | 207,000   | 184,000   | 60,000    | 160,000   | 141,000   | 80,000    | 197,000   | 306,000   |
| October, . . . . .         | 646,000   | 234,000   | 632,000   | 516,000   | 71,000    | 101,000   | 186,000   | 299,000   |
| November, . . . . .        | 1,302,000 | 1,088,000 | 1,418,000 | 1,693,000 | 206,000   | 205,000   | 395,000   | 210,000   |
| December, . . . . .        | 584,000   | 454,000   | 1,289,000 | 3,177,000 | 462,000   | 175,000   | 775,000   | 314,000   |
| Average for whole year,    | 972,000   | 1,135,000 | 1,214,000 | 1,452,000 | 894,000   | 578,000   | 979,000   | 862,000   |
| Av. for driest six months, | 574,000   | 384,000   | 502,000   | 532,000   | 230,000   | 143,000   | 330,000   | 211,000   |

| MONTH.                     | 1883.     | 1884.     | 1885.     | 1886.     | 1887.     | 1888.     | 1889.     | 1890.     |
|----------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| January, . . . . .         | 335,000   | 995,000   | 1,235,000 | 1,461,000 | 2,580,000 | 1,053,000 | 2,782,000 | 1,254,000 |
| February, . . . . .        | 1,033,000 | 2,842,000 | 1,354,000 | 4,800,000 | 2,829,000 | 1,951,000 | 1,195,000 | 1,529,000 |
| March, . . . . .           | 1,611,000 | 3,785,000 | 1,572,000 | 2,939,000 | 2,868,000 | 3,237,000 | 1,339,000 | 3,643,000 |
| April, . . . . .           | 1,350,000 | 2,853,000 | 1,815,000 | 1,947,000 | 2,620,000 | 2,645,000 | 1,410,000 | 1,875,000 |
| May, . . . . .             | 938,000   | 1,030,000 | 1,336,000 | 720,000   | 1,009,000 | 1,632,000 | 880,000   | 1,366,000 |
| June, . . . . .            | 300,000   | 417,000   | 428,000   | 203,000   | 414,000   | 422,000   | 653,000   | 568,000   |
| July, . . . . .            | 115,000   | 224,000   | 62,000    | 115,000   | 114,000   | 117,000   | 633,000   | 108,000   |
| August, . . . . .          | 78,000    | 257,000   | 240,000   | 94,000    | 214,000   | 380,000   | 1,432,000 | 132,000   |
| September, . . . . .       | 91,000    | 44,000    | 121,000   | 118,000   | 111,000   | 1,155,000 | 824,000   | 458,000   |
| October, . . . . .         | 186,000   | 83,000    | 336,000   | 146,000   | 190,000   | 1,999,000 | 1,230,000 | 2,272,000 |
| November, . . . . .        | 205,000   | 175,000   | 1,178,000 | 673,000   | 368,000   | 2,758,000 | 1,941,000 | 1,215,000 |
| December, . . . . .        | 193,000   | 925,000   | 1,174,000 | 1,020,000 | 643,000   | 3,043,000 | 2,241,000 | 967,000   |
| Average for whole year,    | 533,000   | 1,129,000 | 901,000   | 1,087,000 | 1,164,000 | 1,697,000 | 1,383,000 | 1,285,000 |
| Av. for driest six months, | 145,000   | 200,000   | 391,000   | 223,000   | 234,000   | 953,000   | 944,000   | 747,000   |

\* The area of the Sudbury River watershed used in making up these records included water surfaces amounting to about one per cent. of the whole area, from 1875 to 1878 inclusive, and subsequently increasing by the construction of storage reservoirs to about three per cent. in 1886. The watershed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.



*Field of the Sudbury River Watershed in Gallons per Day per Square Mile—*  
*Concluded.*

| MONTH.                     | 1891.     | 1892.     | 1893.     | 1894.     | 1895.     | Mean for 21<br>Years,<br>1875-1895,<br>Inclusive. |
|----------------------------|-----------|-----------|-----------|-----------|-----------|---------------------------------------------------|
| January, . . . . .         | 3,018,000 | 1,870,000 | 433,000   | 693,000   | 1,034,000 | 1,212,000                                         |
| February, . . . . .        | 3,486,000 | 943,000   | 1,542,000 | 991,000   | 541,000   | 1,845,000                                         |
| March, . . . . .           | 4,453,000 | 1,955,000 | 3,245,000 | 2,238,000 | 2,410,000 | 2,825,000                                         |
| April, . . . . .           | 2,397,000 | 871,000   | 2,125,000 | 1,640,000 | 2,515,000 | 2,953,000                                         |
| May, . . . . .             | 532,000   | 1,259,000 | 2,883,000 | 840,000   | 695,000   | 1,148,000                                         |
| June, . . . . .            | 414,000   | 428,000   | 440,000   | 419,000   | 174,000   | 473,000                                           |
| July, . . . . .            | 149,000   | 214,000   | 158,000   | 161,000   | 231,000   | 187,000                                           |
| August, . . . . .          | 163,000   | 280,000   | 181,000   | 209,000   | 229,000   | 286,000                                           |
| September, . . . . .       | 203,000   | 229,000   | 108,000   | 150,000   | 89,000    | 240,000                                           |
| October, . . . . .         | 210,000   | 126,000   | 221,000   | 374,000   | 1,379,000 | 545,000                                           |
| November, . . . . .        | 305,000   | 697,000   | 319,000   | 836,000   | 2,777,000 | 950,000                                           |
| December, . . . . .        | 544,000   | 485,000   | 797,000   | 716,000   | 1,782,000 | 1,038,000                                         |
| Average for whole year,    | 1,315,000 | 781,000   | 1,087,000 | 770,000   | 1,152,000 | 1,062,000                                         |
| Av. for driest six months, | 239,000   | 327,000   | 237,000   | 356,000   | 456,000   | 398,000                                           |

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**THE HARDNESS OF WATER**

**AND**

**METHODS BY WHICH IT IS DETERMINED.**

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**BY ELLEN H. RICHARDS, S.B.**

*Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected*  
— Continued.

| May, 1895.          |         |          |            |             |                |           |        |          |              | June, 1895.         |         |          |            |             |                |           |        |          |              |
|---------------------|---------|----------|------------|-------------|----------------|-----------|--------|----------|--------------|---------------------|---------|----------|------------|-------------|----------------|-----------|--------|----------|--------------|
| DAY<br>OF<br>MONTH. | Ludlow. | Amherst. | Fitchburg. | Framingham. | Chestnut Hill. | Lawrence. | Salem. | Taunton. | New Bedford. | DAY<br>OF<br>MONTH. | Ludlow. | Amherst. | Fitchburg. | Framingham. | Chestnut Hill. | Lawrence. | Salem. | Taunton. | New Bedford. |
| 1, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            | 1, . . .            | -       | -        | -          | 0.51        | 0.29           | 0.19      | -      | -        | 0.15         |
| 2, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            | 2, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 3, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            | 3, . . .            | -       | -        | 0.06       | *           | *              | *         | 0.10   | 0.11     | 0.12         |
| 4, . . .            | -       | -        | -          | -           | 0.09           | 0.10      | *      | -        | -            | 4, . . .            | 1.20    | -        | 0.28       | *           | 0.11           | 0.09      | -      | 0.16     | 0.30         |
| 5, . . .            | -       | -        | -          | -           | -              | -         | 0.28   | -        | 0.33         | 5, . . .            | -       | *        | -          | *           | -              | *         | -      | *        | -            |
| 6, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            | 6, . . .            | 0.40    | 1.58     | 0.10       | 0.55        | 0.12           | 0.19      | 0.12   | 0.06     | 0.13         |
| 7, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            | 7, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 8, . . .            | 0.05    | 0.21     | 0.06       | -           | -              | -         | -      | -        | -            | 8, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 9, . . .            | -       | -        | -          | 0.05        | -              | -         | -      | 0.05     | 0.01         | 9, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 10, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 10, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 11, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 11, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 12, . . .           | 0.60    | 0.50     | 0.72       | *           | *              | -         | *      | 0.89     | 0.77         | 12, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 13, . . .           | -       | -        | -          | 0.67        | 1.19           | 0.79      | 1.20   | 0.18     | 0.29         | 13, . . .           | -       | -        | 0.40       | 0.16        | -              | -         | -      | -        | -            |
| 14, . . .           | -       | -        | -          | -           | -              | -         | -      | *        | *            | 14, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 15, . . .           | 0.30    | 0.12     | 0.48       | 0.57        | 0.65           | 0.20      | 0.63   | 1.20     | 0.96         | 15, . . .           | -       | -        | -          | 0.08        | -              | -         | -      | -        | -            |
| 16, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 16, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 17, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 17, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 18, . . .           | 0.15    | 0.15     | 0.07       | 0.26        | 0.25           | 0.13      | 0.21   | 0.40     | 0.52         | 18, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 19, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 19, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 20, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 20, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 21, . . .           | -       | -        | -          | -           | -              | -         | 0.08   | *        | *            | 21, . . .           | -       | -        | -          | 0.03        | -              | -         | -      | -        | -            |
| 22, . . .           | -       | -        | -          | -           | -              | -         | -      | 0.31     | 0.65         | 22, . . .           | -       | 0.15     | 0.11       | -           | 0.02           | -         | -      | -        | -            |
| 23, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 23, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 24, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 24, . . .           | -       | 0.18     | -          | -           | -              | -         | -      | -        | -            |
| 25, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 25, . . .           | -       | -        | 0.95       | 0.67        | 0.27           | 0.81      | 0.27   | 0.36     | 1.07         |
| 26, . . .           | 0.20    | *        | 0.20       | 0.08        | 0.10           | *         | 0.13   | 0.20     | 0.49         | 26, . . .           | 0.30    | -        | -          | -           | -              | -         | -      | -        | -            |
| 27, . . .           | 0.70    | 1.00     | 0.79       | 0.26        | 0.30           | 0.11      | -      | 0.40     | 0.29         | 27, . . .           | 0.25    | 0.80     | 0.43       | -           | *              | -         | *      | *        | *            |
| 28, . . .           | -       | -        | -          | -           | -              | 0.22      | *      | -        | -            | 28, . . .           | 0.40    | -        | 0.89       | -           | 1.17           | -         | 2.30   | 1.46     | 1.60         |
| 29, . . .           | -       | -        | -          | -           | -              | -         | 0.21   | -        | -            | 29, . . .           | 0.30    | 0.53     | -          | 1.15        | -              | 1.62      | -      | -        | -            |
| 30, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 30, . . .           | -       | 0.21     | 0.02       | 0.13        | 0.23           | 0.04      | 0.19   | 0.02     | -            |
| 31, . . .           | 0.05    | 0.06     | -          | 0.06        | -              | -         | 0.11   | 0.32     | 0.02         |                     |         |          |            |             |                |           |        |          |              |
| TOTALS,             | 2.05    | 2.03     | 2.32       | 1.94        | 2.58           | 1.55      | 2.80   | 3.95     | 4.23         | TOTALS,             | 2.85    | 3.47     | 3.24       | 3.23        | 2.21           | 2.94      | 2.98   | 2.17     | 3.54         |

\* Precipitation included in that of following day.

*Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected*  
Continued.

| July, 1895.         |         |          |            |             |                |           |        |          |              | August, 1895.       |         |          |            |             |                |           |        |          |              |
|---------------------|---------|----------|------------|-------------|----------------|-----------|--------|----------|--------------|---------------------|---------|----------|------------|-------------|----------------|-----------|--------|----------|--------------|
| DAY<br>OF<br>MONTH. | Ludlow. | Amherst. | Fitchburg. | Framingham. | Chestnut Hill. | Lawrence. | Salem. | Taunton. | New Bedford. | DAY<br>OF<br>MONTH. | Ludlow. | Amherst. | Fitchburg. | Framingham. | Chestnut Hill. | Lawrence. | Salem. | Taunton. | New Bedford. |
| 1, . . .            | -       | -        | 0.06       | -           | -              | 0.07      | 0.05   | 0.06     | 0.55         | 1, . . .            | -       | 0.04     | -          | -           | -              | -         | -      | -        | -            |
| 2, . . .            | 0.20    | -        | -          | -           | -              | -         | -      | -        | -            | 2, . . .            | -       | -        | -          | 0.16        | 0.01           | 0.03      | 0.20   | 0.05     | -            |
| 3, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            | 3, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 4, . . .            | 0.30    | -        | 0.05       | 0.32        | 0.50           | *         | *      | 0.75     | 0.75         | 4, . . .            | -       | -        | 0.02       | -           | -              | -         | -      | -        | -            |
| 5, . . .            | -       | -        | 0.06       | *           | -              | 0.06      | 0.16   | -        | -            | 5, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 6, . . .            | *       | 0.36     | 0.44       | 0.80        | 0.40           | 0.19      | 0.04   | 0.41     | 0.60         | 6, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 7, . . .            | 0.60    | -        | -          | -           | -              | -         | -      | -        | -            | 7, . . .            | 0.30    | 0.38     | 0.34       | 1.34        | 1.48           | 0.36      | 2.32   | 0.83     | 0.62         |
| 8, . . .            | -       | -        | -          | -           | -              | -         | 0.04   | -        | -            | 8, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 9, . . .            | -       | 0.83     | 4.13       | 0.40        | 1.31           | 0.81      | 1.35   | 0.86     | 0.10         | 9, . . .            | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 10, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 10, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 11, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 11, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 12, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 12, . . .           | -       | 0.20     | 0.26       | 0.30        | 0.44           | 0.31      | 0.18   | 0.79     | 1.05         |
| 13, . . .           | 1.20    | 0.44     | 0.28       | 0.43        | 0.45           | 0.54      | *      | 0.26     | 0.40         | 13, . . .           | -       | -        | 0.04       | -           | -              | -         | -      | -        | -            |
| 14, . . .           | -       | -        | 0.04       | 0.08        | -              | 0.21      | 0.51   | -        | 0.74         | 14, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 15, . . .           | -       | -        | -          | -           | -              | -         | 0.07   | -        | -            | 15, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 16, . . .           | -       | 0.23     | 0.10       | 0.06        | 0.05           | *         | *      | 0.53     | 0.24         | 16, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 17, . . .           | -       | -        | -          | -           | -              | 0.03      | 0.07   | -        | -            | 17, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 18, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 18, . . .           | 1.50    | 1.70     | 0.77       | 1.21        | 1.17           | 1.44      | 1.67   | 1.21     | 0.77         |
| 19, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 19, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 20, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 20, . . .           | -       | -        | -          | 0.03        | -              | -         | -      | -        | -            |
| 21, . . .           | -       | 0.27     | -          | -           | -              | -         | -      | -        | -            | 21, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | 0.04         |
| 22, . . .           | 0.00    | -        | -          | 0.38        | 0.18           | 0.13      | 0.02   | -        | 0.06         | 22, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 23, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 23, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 24, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 24, . . .           | *       | -        | 0.08       | 0.01        | 0.01           | 0.09      | -      | -        | -            |
| 25, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 25, . . .           | 0.10    | -        | -          | -           | -              | -         | -      | -        | -            |
| 26, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 26, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 27, . . .           | 2.20    | 1.02     | 0.31       | 0.12        | -              | *         | *      | -        | *            | 27, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 28, . . .           | -       | -        | 0.34       | -           | 0.03           | 0.30      | 0.09   | 0.23     | 0.02         | 28, . . .           | 0.10    | 0.42     | -          | 0.18        | -              | -         | -      | 0.19     | 0.02         |
| 29, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            | 29, . . .           | -       | -        | 0.14       | 0.02        | 0.08           | 0.02      | -      | -        | -            |
| 30, . . .           | 0.95    | 0.23     | 0.45       | 2.58        | 0.63           | 0.87      | 1.36   | 0.46     | 1.38         | 30, . . .           | -       | -        | -          | -           | -              | -         | -      | -        | -            |
| 31, . . .           | -       | -        | 0.01       | -           | -              | -         | -      | -        | -            | 31, . . .           | 0.90    | -        | 0.44       | 0.75        | 0.72           | 0.24      | 0.59   | 0.70     | -            |
| TOTALS,             | 6.35    | 3.38     | 6.26       | 5.17        | 3.55           | 3.21      | 3.76   | 3.56     | 4.84         | TOTALS,             | 2.90    | 2.74     | 2.09       | 4.00        | 3.91           | 2.49      | 4.96   | 3.77     | 2.51         |

\* Precipitation included in that of following day.

If calcium carbonate and chloride were the only salts to be met with, or if calcium and magnesium salts occurred separately in waters, the results would be quantitative ; but, as the salts usually occur mixed in unknown proportions, the figures given under the heading “ hardness ” are accurate only within limits.

As recorded in the reports of the State Board of Health, the figures under “ hardness ” indicate the number of grams of calcium carbonate which, dissolved in 100,000 grams (100 litres) of distilled water, would decompose as much soap as would 100 litres of the water in question. If the mineral salt was magnesium carbonate or calcium sulphate, the figure would be slightly different ; and if two or three of these compounds were present, yet a different figure would be given. Ordinary soaps contain from 23 to 31 per cent. of water, and in combining power have been found to vary from 75 to 90 per cent. of the value of the standard soap used in the determinations, with a tendency to the lower limit. Not to burden this paper with the long series of experiments and calculations made, it may be said that, on an average which includes some wide variations, the weight of soap required to give a lather which will remain five minutes is ten to twelve times the weight of the calcium and magnesium salts.

From the figures under the heading “ hardness,” in the tabulated analyses, an estimate may be made as follows : —

If the hardness of a water is given as 9.0, it means that in 100,000 pounds of water there is, of calcium and magnesium salts, a quantity which gives the same hardness to water which would be given by 9 pounds of calcium carbonate. In order to soften this water for manufacturing purposes about 9 pounds of soda ash will be required, and for laundry purposes about 90 pounds of soap.

Massachusetts is, as regards hardness, exceptionally fortunate in her water supplies. Of 153 sources supplying 143 cities and towns, only 13 per cent. show over 4 parts per 100,000 of hardness, while half of the remaining 87 per cent. have a hardness below 1.5 parts, and 13.7 per cent. of the whole number have a hardness of less than 0.5 of one part. Of the 19 supplies which have a hardness of more than 4, six are between 4 and 5, four are between 5 and 6, three are between 6 and 10, one is between 10 and 15, five are over 15.

## METHODS OF DETERMINATION OF HARDNESS.

1. *By Soap, — Clark's Method.*

When potassium or sodium soap is added to water containing calcium and magnesium salts, the soap is decomposed, and insoluble compounds with the fatty acids are produced.

Upon this decomposition of soap is based the method for the determination of "lime salts" which was perfected and patented by Thomas Clark \* in 1841. Variouslly modified by French, German and English chemists, the principles he formulated proved of general application. He employed sixteen standard calcium carbonate solutions, containing from one to sixteen "degrees of hardness," one degree meaning one grain of calcium carbonate to the imperial gallon. The soap solution was prepared by dissolving hard soap in proof spirits and making up to such a strength that 100 test measures of the standard calcium carbonate solution of 16 degrees of hardness should take 32 test measures of soap solution, a test measure being  $\frac{1}{1000}$  part of a gallon.

Hardness may be temporary, caused by the presence of bicarbonates which are decomposed by boiling heat, with the liberation of carbon dioxide (carbonic acid), or permanent, caused by compounds other than the bicarbonates. In the Clark process the total hardness is determined on the unboiled water and the permanent on the boiled, the difference being the temporary hardness. The total hardness only is given in the results tabulated in the State Board of Health reports.

The solutions used in the laboratory for water analysis are made as follows: —

A standard calcium chloride solution is prepared by dissolving 0.2 gram of Iceland spar in dilute hydrochloric acid in a platinum dish and evaporating to dryness, redissolving in a small amount of water and again evaporating to dryness. This is repeated several times, until all the free acid is removed and a perfectly neutral salt remains which is dissolved in water and made up to one litre. One cubic centimeter then contains calcium chloride equivalent to 0.0002 gram calcium carbonate.

For the preparation of the standard soap solution 100 grams of the best quality of dry, white Castile soap is cut into thin shavings, dissolved in dilute alcohol (500 cubic centimeters alcohol, 96 per

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\* Clark's Process, Repertory Patent Inventions, 1841.

cent., and 500 cubic centimeters of distilled water) and allowed to stand over night to settle; 100 cubic centimeters of the clear liquid are then made up to two litres, enough alcohol being used to keep all of the soap in solution. Fifty cubic centimeters of the standard solution of calcium chloride, which, according to the table, should take exactly 14.25 cubic centimeters of standard soap, are used to test its strength. The solution thus prepared does not change perceptibly if air has no access to it, and, if used with a siphon burette attached to the bottle, will keep for five or six weeks or longer. It contains 5.2 grams of Castile soap to the litre.

For the standardization of the soap and for the determination of the hardness of any water, 50 cubic centimeters of the water to be tested or of the standard calcium chloride solution are placed in a flask or bottle of 200 cubic centimeters capacity and of a convenient shape, and the soap solution added, two or three tenths of a cubic centimeter at a time, shaking well after each addition, until a lather is obtained which is permanent for five minutes, and covers the entire surface of the liquid with the bottle placed on its side.

The following table gives the hardness corresponding to the number of cubic centimeters of soap solution used in the analyses:—

*Table of Hardness.*

| Volume of Soap<br>Sol. c.c. | Hardness.<br>(Ca CO <sub>3</sub> per<br>100,000.) | Volume of Soap<br>Sol. c.c. | Hardness.<br>(Ca CO <sub>3</sub> per<br>100,000.) | Volume of Soap<br>Sol. c.c. | Hardness.<br>(Ca CO <sub>3</sub> per<br>100,000.) |
|-----------------------------|---------------------------------------------------|-----------------------------|---------------------------------------------------|-----------------------------|---------------------------------------------------|
| 0.7                         | 0.00                                              | 3.7                         | 4.16                                              | 6.7                         | 8.43                                              |
| 0.8                         | 0.16                                              | 3.8                         | 4.29                                              | 6.8                         | 8.57                                              |
| 0.9                         | 0.32                                              | 3.9                         | 4.43                                              | 6.9                         | 8.71                                              |
| 1.0                         | 0.48                                              | 4.0                         | 4.57                                              | 7.0                         | 8.86                                              |
| 1.1                         | 0.63                                              | 4.1                         | 4.71                                              | 7.1                         | 9.00                                              |
| 1.2                         | 0.79                                              | 4.2                         | 4.86                                              | 7.2                         | 9.14                                              |
| 1.3                         | 0.95                                              | 4.3                         | 5.00                                              | 7.3                         | 9.29                                              |
| 1.4                         | 1.11                                              | 4.4                         | 5.14                                              | 7.4                         | 9.43                                              |
| 1.5                         | 1.27                                              | 4.5                         | 5.29                                              | 7.5                         | 9.57                                              |
| 1.6                         | 1.43                                              | 4.6                         | 5.43                                              | 7.6                         | 9.71                                              |
| 1.7                         | 1.58                                              | 4.7                         | 5.57                                              | 7.7                         | 9.86                                              |
| 1.8                         | 1.69                                              | 4.8                         | 5.71                                              | 7.8                         | 10.00                                             |
| 1.9                         | 1.82                                              | 4.9                         | 5.86                                              | 7.9                         | 10.15                                             |
| 2.0                         | 1.95                                              | 5.0                         | 6.00                                              | 8.0                         | 10.30                                             |
| 2.1                         | 2.08                                              | 5.1                         | 6.14                                              | 8.1                         | 10.45                                             |
| 2.2                         | 2.21                                              | 5.2                         | 6.29                                              | 8.2                         | 10.60                                             |
| 2.3                         | 2.34                                              | 5.3                         | 6.43                                              | 8.3                         | 10.75                                             |
| 2.4                         | 2.47                                              | 5.4                         | 6.57                                              | 8.4                         | 10.90                                             |
| 2.5                         | 2.60                                              | 5.5                         | 6.71                                              | 8.5                         | 11.05                                             |
| 2.6                         | 2.73                                              | 5.6                         | 6.86                                              | 8.6                         | 11.20                                             |
| 2.7                         | 2.86                                              | 5.7                         | 7.00                                              | 8.7                         | 11.35                                             |
| 2.8                         | 2.99                                              | 5.8                         | 7.14                                              | 8.8                         | 11.50                                             |
| 2.9                         | 3.12                                              | 5.9                         | 7.29                                              | 8.9                         | 11.65                                             |
| 3.0                         | 3.25                                              | 6.0                         | 7.43                                              | 9.0                         | 11.80                                             |
| 3.1                         | 3.38                                              | 6.1                         | 7.57                                              | 9.1                         | 11.95                                             |
| 3.2                         | 3.51                                              | 6.2                         | 7.71                                              | 9.2                         | 12.11                                             |
| 3.3                         | 3.64                                              | 6.3                         | 7.86                                              | 9.3                         | 12.26                                             |
| 3.4                         | 3.77                                              | 6.4                         | 8.00                                              | 9.4                         | 12.41                                             |
| 3.5                         | 3.90                                              | 6.5                         | 8.14                                              | 9.5                         | 12.56                                             |
| 3.6                         | 4.03                                              | 6.6                         | 8.29                                              |                             |                                                   |

The importance of adding the soap solution in small quantities cannot be too strongly emphasized, especially in the presence of magnesium compounds. If much carbonic acid be liberated, it is well to follow the original directions and remove it by suction. It will be observed that the table does not admit of the determination of hardness above 12.5 parts. In case the water under examination requires more than 10 cubic centimeters of the standard soap solution, a smaller portion of 25 cubic centimeters, 10 cubic centimeters, or even 2 cubic centimeters, as the case may require, is measured out and made up to a volume of 50 cubic centimeters with recently distilled water. This will keep the results comparable with each other, although the element of dilution introduces a slight error into the calculation.

## 2. *By Acid, — Hehner's Method.*

Attempts have been made to determine the calcium and magnesium salts by means of standard acid and alkaline solutions instead of by soap. An exhaustive study of the relative practical value of one of these, as compared with the soap method, was made in 1890 in the laboratory of the State Board of Health. A condensed summary of the results is here given.

The standard solutions used are sodium carbonate, 1.06 grams to the litre, one cubic centimeter corresponding to 0.0001 gram calcium carbonate, and sulphuric acid of such a strength that one cubic centimeter will exactly neutralize one cubic centimeter of the standard sodium carbonate (0.98 gram of sulphuric acid to one litre).

For the determination of the temporary hardness, 100 cubic centimeters of the water to be tested, tinted with lacmoid, which is the best indicator to use with surface waters, are heated nearly to boiling in a porcelain dish, and the standard acid added to a neutral reaction. Each cubic centimeter of acid corresponds to one part of calcium carbonate per 100,000.

For the permanent hardness, another 100 cubic centimeters of water are taken, and enough of the standard sodium carbonate solution added to more than decompose the salts of calcium and magnesium, and the whole evaporated to dryness in a platinum or nickel dish. (Glass and porcelain cannot be used, as too large an error is introduced from the alkali dissolved from these substances.) The residue is first treated with boiling distilled water, which has been boiled for a few minutes to remove any carbonic acid, and then



filtered through a small filter which must be well washed, the filtrate tinted with lacmoid and the excess of free alkali determined by the standard acid.\*

The number of cubic centimeters of sodium carbonate used, less the acid used for neutralization, gives the permanent, and the sum of the two gives the total, hardness.

With alkaline waters, with sewage and with some sewage effluents, a correction must be made for the excess of alkaline carbonates; but in these cases the results after correction do not compare as closely with the soap method as do those obtained with the natural waters.

The following tabulated results were obtained by the two methods, which were tried on a number of ground and surface waters and several samples of sewage, in every case the total hardness being given:—

*Surface Waters.*

[Parts per 100,000.]

| PLACE OF COLLECTION.                                                         | Total Hardness by Soap. | Total Hardness by Acid. |
|------------------------------------------------------------------------------|-------------------------|-------------------------|
| Fitchburg, Overlook Reservoir, . . . . .                                     | 0.48                    | 0.70                    |
| Springfield, Ludlow Reservoir, 6 feet beneath the surface, . . . . .         | 0.79                    | 1.11                    |
| Springfield, Ludlow Reservoir, at surface, . . . . .                         | 0.79                    | 1.00                    |
| Quincy, Reservoir, . . . . .                                                 | 0.79                    | 0.80                    |
| Lawrence, Merrimack River, . . . . .                                         | 0.80                    | 1.11                    |
| Brockton, Reservoir, . . . . .                                               | 0.90                    | 0.80                    |
| Quincy, inlet to Reservoir, . . . . .                                        | 0.95                    | 0.70                    |
| Worcester, Holden Reservoir, . . . . .                                       | 0.95                    | 1.10                    |
| Millville, Blackstone River, . . . . .                                       | 1.10                    | 1.60                    |
| Boston Water Works, Basin 4, 20 feet beneath the surface, . . . . .          | 1.11                    | 1.11                    |
| Boston Water Works, Basin 4, 4 feet beneath the surface, . . . . .           | 1.27                    | 1.00                    |
| Lawrence, Merrimack River, . . . . .                                         | 1.30                    | 1.60                    |
| Boston Water Works, Cold Spring Brook, at head of Reservoir No. 4, . . . . . | 1.43                    | 1.40                    |
| Boston Water Works, Reservoir No. 2, . . . . .                               | 1.46                    | 1.45                    |
| Boston Water Works, Sudbury River, at head of Reservoir No. 2, . . . . .     | 1.56                    | 1.30                    |
| Boston Water Works, Reservoir No. 4, near bottom, . . . . .                  | 1.56                    | 1.55                    |
| Boston Water Works, Reservoir No. 3, . . . . .                               | 1.80                    | 1.90                    |
| Frammingham, Farm Pond, . . . . .                                            | 1.95                    | 1.90                    |
| Marlborough, . . . . .                                                       | 2.30                    | 2.00                    |
| Boston Water Works, Stony Brook, at head of Reservoir No. 3, . . . . .       | 2.34                    | 2.35                    |
| Winchester, Reservoir, . . . . .                                             | 2.60                    | 2.70                    |
| Worcester, Blackstone River, . . . . .                                       | 2.86                    | 2.90                    |
| Poughkeepsie, inlet of filter-basin, . . . . .                               | 4.00                    | 4.00                    |
| Poughkeepsie, inlet of east filter-bed, . . . . .                            | 4.00                    | 4.00                    |
| Poughkeepsie, inlet of west filter-bed, . . . . .                            | 4.00                    | 4.00                    |
| Poughkeepsie, Hudson River, . . . . .                                        | 4.57                    | 4.50                    |

\* Analyst, vol. viii, 77, 1883.

These two methods were then tried upon three samples of sewage, the results of which show wide differences :—

| PLACE OF COLLECTION. | Total Hardness by Soap. | Total Hardness by Acid. |
|----------------------|-------------------------|-------------------------|
| No. 1, . . . . .     | 4.20                    | 5.80                    |
| No. 2, . . . . .     | 3.90                    | 7.20                    |
| No. 3, . . . . .     | 3.60                    | 5.60                    |

These three samples were strongly alkaline, in every case the acid method giving the higher results.

*Ground Waters.*

| PLACE OF COLLECTION.      | Hardness by Soap. | Hardness by Acid. | PLACE OF COLLECTION.           | Hardness by Soap. | Hardness by Acid. |
|---------------------------|-------------------|-------------------|--------------------------------|-------------------|-------------------|
| Whitman, well, . .        | 1.80              | 1.70              | Woburn, well, . .              | 4.90              | 4.40              |
| Whately, well, . .        | 2.08              | 2.00              | Winchester, well, . .          | 5.10              | 6.80              |
| South Deerfield, well, .  | 2.21              | 1.95              | Hatfield, well, . .            | 5.14              | 4.70              |
| Melrose, well, . .        | 2.30              | 2.40              | South Deerfield, well, .       | 5.71              | 5.40              |
| Melrose, well, . .        | 2.50              | 3.20              | South Deerfield, well, .       | 5.71              | 5.42              |
| Greenfield, well, . .     | 2.73              | 2.20              | Hatfield, well, . .            | 6.00              | 6.30              |
| Melrose, well, . .        | 2.90              | 3.50              | Williamsburg, well, .          | 6.29              | 8.80              |
| Framingham, filter-basin, | 3.10              | 3.10              | Winter Hill, well, . .         | 7.00              | 7.70              |
| Orange, well, . .         | 3.40              | 3.40              | Malden, well, . .              | 7.10              | 7.30              |
| Melrose, well, . .        | 3.50              | 4.70              | South Framingham, under-drain. | 7.70              | 7.70              |
| Reading, well, . .        | 3.60              | 4.90              | Malden, well, . .              | 7.90              | 8.80              |
| Malden, well, . .         | 3.60              | 5.00              | Reading, well, . .             | 10.00             | 10.10             |
| Cambridge, well, . .      | 4.20              | 5.80              | Framingham, well, . .          | 10.10             | 9.80              |
| Cambridge, well, . .      | 4.40              | 4.90              | Reading, well, . .             | 11.50             | 10.50             |
| Boston, well, . .         | 4.40              | 4.90              | Amherst, well, . .             | 12.56             | 12.30             |
| Williamsburg, well, .     | 4.57              | 4.20              | Williamstown, spring, .        | 34.40             | 30.35             |
| Reading, well, . .        | 4.60              | 4.50              | Chelsea, well, . .             | 17.30             | 17.10             |
| Saugus, well, . .         | 4.70              | 6.30              | Chelsea, well, . .             | 17.50             | 17.40             |
| Amherst, well, . .        | 4.71              | 4.45              | Williamstown, well, .          | 34.40             | 30.35             |

The extent to which the presence of magnesium salts affects the results is well shown in the following table, which gives not only the total hardness but the amount of each salt which caused it, as deter-

mined by analysis. It is possible by careful manipulation to precipitate the calcium by means of ammonium oxalate, and, after filtering, to determine the hardness due to the remaining magnesium salts.

[Parts per 100,000.]

|                                  | Total Solids. | Ca CO <sub>3</sub> . | Mg CO <sub>3</sub> . | Solids causing Hardness. | Hardness by Soap. |
|----------------------------------|---------------|----------------------|----------------------|--------------------------|-------------------|
| Swampscott, tubular wells, . . . | 21.10         | 6.71                 | 3.02                 | 9.73                     | 10.00             |
| Swampscott, tubular wells, . . . | 20.10         | 6.05                 | 3.05                 | 9.10                     | 9.10              |
| Swampscott, large well, . . . .  | 34.00         | 9.91                 | 4.21                 | 14.12                    | 14.37             |
| Marblehead, large well, . . . .  | 13.70         | 3.32                 | 1.51                 | 4.83                     | 4.85              |
| Marblehead, tubular wells, . . . | 39.10         | 8.45                 | 4.05                 | 12.50                    | 12.86             |

The foregoing results show that the simpler soap method gives results agreeing fairly well with the more tedious acid method, and it is therefore desirable to retain it for regular use in determining the hardness of waters for domestic use. It has, moreover, the advantage of being a more direct expression of the amount of soap wasted in using a water.

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**EXPERIMENTS**

**UPON THE**

**PURIFICATION OF SEWAGE AND WATER**

**AT THE**

**LAWRENCE EXPERIMENT STATION,**

**DURING THE YEAR 1895.**

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# EXPERIMENTS UPON THE PURIFICATION OF SEWAGE AND WATER AT THE LAWRENCE EXPERIMENT STATION.\*

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By HARRY W. CLARK, Chemist in Charge.

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The year 1895 is the eighth that the experimental work of the Lawrence Experiment Station has been continued. The work has been carried on under the general supervision of Hiram F. Mills, A.M., C.E., a member of the State Board of Health. Mr. Geo. W. Fuller, biologist, was in direct charge of the station until August, 1895, when the writer, who had previously been in charge of the chemical department, succeeded Mr. Fuller in charge of the station. Mr. W. R. Copeland is in charge of the biological department, with Mr. Lewis Weinberg as assistant biologist. Mr. F. B. Forbes is assistant chemist. Profs. T. M. Drown and W. T. Sedgwick, of the Massachusetts Institute of Technology, have been, respectively, consulting chemist and biologist, having a general oversight of the chemical and biological investigations.

The investigations at the Lawrence Experiment Station during the year 1895 have been along the same general lines as in previous years, and additional and valuable data upon the subjects of sewage and water purification have been obtained. The question of the permanency of sewage filters and the best methods of management to secure this permanency, preliminary treatment of sewage by different methods to remove sludge before filtration, and different methods of aerating sewage filters to secure the greatest efficiency, quantitative and qualitative, have been studied. In addition to this, studies of the composition of sewage have been continued, and investigations of methods for the disposal or utilization of waste liquors of industrial works have been begun.

The investigations upon water filtration have been directed towards the subjects of high rates of filtration and the effectiveness of shallow

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\* A full account of the work done at the Lawrence Experiment Station for the years 1888 and 1889 is contained in a special report of the State Board of Health upon the Purification of Sewage and Water, 1890. A similar account for the years 1890 and 1891 is contained in the twenty-third annual report of the Board for the year 1891. Since 1891 the results have been published yearly in the annual reports.

filters compared with deeper, the influence of period of use upon the qualitative and quantitative efficiency of filters, the efficiency of sands of a character not before used, and studies of the operation and results — chemical, bacterial and hygienic — obtained by the Lawrence city filter. A portion of the investigation into the condition of the Neponset River has been carried out by the force employed at the laboratories of the station.

### FILTRATION OF SEWAGE.

The sewage applied to the experimental filters is drawn through a 2.5 inch pipe, 4,300 feet long, from the Lawrence Street sewer at a point just below the main business street of the city and just above the entrance of wastes from the large mills. This sewer drains the streets, houses and stores of the most densely populated section of the city.

When the investigations at the station were begun, the sewage drawn from this sewer was of a composition and strength quite different from the sewage used at the present time. There are a number of reasons for this change, the most important being the use at the present time of *day* sewage only at the station, and a large increase in the number of house connections with the sewer. Low rainfall and a smaller consumption of water per capita also have an influence.

*Table showing Comparison of Average Analyses of Sewage applied to Experimental Filters at Different Periods.*

[Parts per 100,000.]

| PERIOD.              | Free Ammonia. | ALBUMINOID AMMONIA. |          |            | Chlorine. | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|----------------------|---------------|---------------------|----------|------------|-----------|------------------|--------------------------------|
|                      |               | Total.              | Soluble. | Insoluble. |           |                  |                                |
| 1895, . . . . .      | 4.05          | 1.00                | .28      | .72        | 11.43     | 5.10             | 2,907,000                      |
| 1894, . . . . .      | 3.43          | 0.63                | .26      | .37        | 8.07      | 3.86             | 1,330,000                      |
| 1888-1893, . . . . . | 2.09          | 0.67                | .30      | .37        | 6.64      | 3.64             | 870,000                        |

### COMPOSITION OF SEWAGE AND RESULTS OF ANALYSES OF SEWAGE APPLIED TO EXPERIMENTAL FILTERS.

The above table shows that the sewage of 1894 was stronger than the sewage of the six preceding years, and that during 1895 it was still stronger than in 1894. The quantity of free ammonia

and the numbers of bacteria present have both largely increased, the total albuminoid ammonia is much greater than heretofore, while the quantity of insoluble albuminoid ammonia is nearly double that of any previous year. Analyses of samples of sewage collected directly from the Lawrence Street sewer, at the point where the pipe from the sewer to the station begins, have been made each week during the year. These samples have been collected almost invariably between eight and nine o'clock in the morning, when the strongest sewage of the day is passing through the sewer. The results of the monthly averages of these analyses are given in the next table, and the second table beyond shows the results of the monthly analyses of the regular station sewage. The greater quantity of free ammonia and the lower quantity of oxygen consumed in the station sewage are due to the slow passage of the sewage through the 2.5 inch pipe from the sewer to the station, with the consequent bacterial and chemical changes. It will also be noticed that the sewage taken directly from the Lawrence Street sewer has invariably contained nitrogen in the form of nitrates and nitrites and also free dissolved oxygen, and that these substances have disappeared when the sewage reaches the station.

*Monthly Averages of Analyses of Sewage from the Lawrence Street Sewer.*

[Parts per 100,000.]

| 1895.          | Temperature.<br>Deg. F. | Free<br>Ammonia. | ALBUMINOID AMMONIA. |          |            | Chlorine. | NITROGEN AS |           | Oxygen<br>Consumed. | Bacteria per<br>Cubic Centi-<br>meter. |
|----------------|-------------------------|------------------|---------------------|----------|------------|-----------|-------------|-----------|---------------------|----------------------------------------|
|                |                         |                  | Total.              | Soluble. | Insoluble. |           | Nitrates.   | Nitrites. |                     |                                        |
| January, . .   | 48                      | 3.93             | 1.19                | .63      | .56        | 7.71      | .17         | .0115     | 7.75                | 3,830,000                              |
| February, . .  | 46                      | 2.70             | 1.02                | .64      | .38        | 9.19      | .15         | .0140     | 6.10                | 1,277,000                              |
| March, . . .   | 46                      | 2.37             | 1.02                | .68      | .34        | 12.56     | .25         | .0220     | 6.84                | 1,328,000                              |
| April, . . .   | 46                      | 2.50             | 1.07                | .62      | .45        | 10.66     | .25         | .0185     | 8.90                | 1,687,000                              |
| May, . . . .   | 56                      | 2.87             | .99                 | .54      | .45        | 21.78     | .25         | .0342     | 5.16                | 3,836,000                              |
| June, . . . .  | 63                      | 3.28             | .93                 | .45      | .48        | 16.92     | .09         | .0175     | 5.45                | 3,712,000                              |
| July, . . . .  | 67                      | 3.73             | .94                 | .47      | .47        | 17.67     | .14         | .0108     | 5.98                | 2,410,000                              |
| August, . . .  | 71                      | 1.78             | .78                 | .39      | .34        | 9.73      | .09         | .0000     | 5.95                | 3,870,000                              |
| September, .   | 72                      | 2.10             | .94                 | .47      | .47        | 11.03     | .18         | .0000     | 6.78                | 1,938,000                              |
| October, . . . | 60                      | 2.27             | .74                 | .47      | .27        | 10.18     | .17         | .0350     | 6.52                | 1,892,000                              |
| November, . .  | 61                      | 1.91             | .76                 | .51      | .25        | 7.91      | .19         | .0000     | 5.30                | 2,217,000                              |
| December, . .  | 53                      | 2.21             | .86                 | .56      | .30        | 7.96      | .23         | .0146     | 7.72                | 3,716,000                              |
| Average, . .   | 57                      | 2.64             | .93                 | .54      | .43        | 11.94     | .18         | .0148     | 6.54                | 2,642,750                              |



On at least four days in each week a bottle of sewage has been taken for analysis from a large tank of sewage at the station, and this sewage is known as the "regular" sewage.

*Monthly Averages of Analyses of Regular Sewage Samples.*

[Parts per 100,000.]

| 1895.                | Temperature,<br>Degrees F. | Free<br>Ammonia. | ALBUMINOID AMMONIA. |          |            | Chlorine. | Oxygen<br>Consumed. | Bacteria per<br>Cubic Centi-<br>meter. |
|----------------------|----------------------------|------------------|---------------------|----------|------------|-----------|---------------------|----------------------------------------|
|                      |                            |                  | Total.              | Soluble. | Insoluble. |           |                     |                                        |
| January, . . . . .   | 41                         | 3.57             | 1.21                | .30      | 0.91       | 9.08      | 6.81                | 2,654,000                              |
| February, . . . . .  | 41                         | 3.71             | 0.99                | .33      | 0.66       | 11.40     | 5.44                | 1,678,000                              |
| March, . . . . .     | 44                         | 4.03             | 0.87                | .33      | 0.49       | 9.42      | 5.82                | 1,916,000                              |
| April, . . . . .     | 45                         | 3.82             | 0.88                | .30      | 0.58       | 8.96      | 5.44                | 2,113,000                              |
| May, . . . . .       | 58                         | 3.71             | 0.57                | .22      | 0.35       | 10.53     | 3.49                | 2,298,000                              |
| June, . . . . .      | 69                         | 4.24             | 1.05                | .25      | 1.70       | 13.07     | 3.50                | 3,431,000                              |
| July, . . . . .      | 69                         | 4.41             | 0.89                | .23      | 0.66       | 14.37     | 5.19                | 2,909,000                              |
| August, . . . . .    | 70                         | 4.31             | 1.02                | .23      | 0.79       | 16.98     | 5.63                | 3,422,000                              |
| September, . . . . . | 68                         | 4.58             | 1.03                | .25      | 0.78       | 14.57     | 5.44                | 3,073,000                              |
| October, . . . . .   | 54                         | 4.21             | 0.87                | .27      | 0.60       | 10.47     | 5.34                | 3,037,000                              |
| November, . . . . .  | 54                         | 3.93             | 0.76                | .23      | 0.47       | 9.47      | 4.10                | 3,144,000                              |
| December, . . . . .  | 48                         | 4.10             | 0.95                | .37      | 0.58       | 8.83      | 5.02                | 5,213,000                              |
| Average, . . . . .   | 55                         | 4.05             | 1.00                | .28      | 0.72       | 11.43     | 5.10                | 2,907,000                              |

OTHER SAMPLES OF SEWAGE COLLECTED FOR ANALYSIS.

In addition to the sewages represented by the preceding tables, it has been the practice to collect other representative samples for analysis, as follows:—

1. A sample representing an average of all the sewage pumped on each Tuesday of the year.

2. Samples representing an average of all the sewage applied to filters Nos. 1, 6 and 9 A.

3. On each Tuesday of the year a sample of the supernatant liquid, after allowing regular sewage to stand for four hours.

4. On each Tuesday of the year a sample of the supernatant liquid, after treating the regular sewage of the day with sulphate of alumina in the proportion of 1,000 pounds per 1,000,000 gallons, and allowing to stand and settle for four hours.

5. On each Tuesday of the year a sample of the liquid resulting from straining regular sewage through a layer of coke breeze.

*Monthly Averages of Analyses of Average Sewage Samples.*

[Parts per 100,000.]

| 1895.                | Free Ammonia. | ALBUMINOID AMMONIA. |          |            | Chlorine. | Oxygen Consumed. | Fats. |
|----------------------|---------------|---------------------|----------|------------|-----------|------------------|-------|
|                      |               | Total.              | Soluble. | Insoluble. |           |                  |       |
| January, . . . . .   | 3.85          | .72                 | .35      | .37        | 7.53      | 3.98             | 4.1   |
| February, . . . . .  | 4.20          | .87                 | .42      | .45        | 10.56     | 4.80             | 5.7   |
| March, . . . . .     | 3.70          | .76                 | .38      | .37        | 8.50      | 4.97             | 3.9   |
| April, . . . . .     | 3.45          | .77                 | .34      | .43        | 10.97     | 5.00             | -     |
| May, . . . . .       | 4.43          | .77                 | .33      | .44        | 19.61     | 3.33             | 3.1   |
| June, . . . . .      | 4.79          | .83                 | .35      | .48        | 12.85     | 4.17             | 4.4   |
| July, . . . . .      | 4.14          | .66                 | .23      | .37        | 15.37     | 3.54             | 5.7   |
| August, . . . . .    | 3.91          | .64                 | .20      | .34        | 12.71     | 3.70             | 3.1   |
| September, . . . . . | 5.24          | .77                 | .23      | .49        | 14.30     | 4.27             | 6.4   |
| October, . . . . .   | 4.00          | .70                 | .23      | .42        | 11.21     | 2.75             | 2.3   |
| November, . . . . .  | 3.99          | .73                 | .33      | .35        | 9.27      | 3.93             | 7.1   |
| December, . . . . .  | 4.14          | .74                 | .42      | .32        | 10.71     | 4.94             | 3.1   |
| Average, . . . . .   | 4.15          | .74                 | .33      | .40        | 11.97     | 4.12             | 4.4   |

*Monthly Averages of Mixed Samples, representing all of the Sewage applied to Filters Nos. 1, 6 and 9 A.*

[Parts per 100,000.]

| 1895.                | FREE AMMONIA. |               |                 | ALBUMINOID AMMONIA. |               |                 | OXYGEN CONSUMED. |               |                 | CHLORINE.     |               |                 |
|----------------------|---------------|---------------|-----------------|---------------------|---------------|-----------------|------------------|---------------|-----------------|---------------|---------------|-----------------|
|                      | Filter No. 1. | Filter No. 6. | Filter No. 9 A. | Filter No. 1.       | Filter No. 6. | Filter No. 9 A. | Filter No. 1.    | Filter No. 6. | Filter No. 9 A. | Filter No. 1. | Filter No. 6. | Filter No. 9 A. |
| January, . . . . .   | 4.71          | 3.81          | 4.61            | .95                 | .67           | .81             | 5.55             | 4.38          | 5.38            | 7.55          | 7.85          | 8.20            |
| February, . . . . .  | 4.13          | 4.00          | 4.45            | .41                 | .87           | .85             | 5.40             | 4.50          | 5.48            | 8.83          | 8.80          | 8.89            |
| March, . . . . .     | 3.86          | 3.26          | 4.23            | .87                 | .62           | .89             | 6.10             | 4.78          | 8.45            | 10.84         | 7.87          | 11.10           |
| April, . . . . .     | 3.63          | 3.87          | 4.15            | .90                 | .81           | .86             | 5.80             | 5.33          | 5.43            | 15.66         | 9.04          | 9.03            |
| May, . . . . .       | 3.97          | 4.08          | 4.34            | .66                 | .61           | .69             | 3.75             | 3.40          | 3.30            | 12.66         | 8.93          | 7.88            |
| June, . . . . .      | 4.33          | 4.45          | 4.62            | .74                 | .73           | .73             | 3.74             | 3.64          | 3.64            | 16.32         | 15.00         | 11.15           |
| July, . . . . .      | 4.69          | 4.39          | 4.46            | .60                 | .56           | .59             | 3.80             | 3.20          | 3.43            | 16.57         | 12.25         | 14.76           |
| August, . . . . .    | 4.29          | 4.11          | 4.40            | .56                 | .55           | .50             | 3.72             | 3.18          | 3.28            | 14.52         | 15.88         | 13.62           |
| September, . . . . . | 4.65          | 4.68          | 4.13            | .76                 | .84           | .69             | 4.43             | 4.33          | 3.93            | 13.31         | 12.48         | 11.93           |
| October, . . . . .   | 4.53          | 3.94          | 4.48            | .75                 | .61           | .75             | 4.35             | 3.30          | 4.38            | 8.79          | 7.49          | 8.41            |
| November, . . . . .  | 4.38          | 4.22          | 4.09            | .80                 | .79           | .74             | 4.84             | 3.70          | 3.76            | 7.75          | 7.18          | 6.93            |
| December, . . . . .  | 4.15          | 3.79          | 3.60            | .90                 | .71           | .65             | 5.90             | 4.48          | 4.10            | 7.92          | 8.31          | 6.96            |
| Average, . . . . .   | 4.29          | 4.05          | 4.29            | .74                 | .68           | .73             | 4.78             | 4.00          | 3.55            | 11.73         | 10.09         | 9.91            |

*Monthly Averages of Analyses of Supernatant Liquid from Settled Sewage, for  
Filter No. 13 A.*

[Parts per 100,000.]

| 1895.                | Free Ammonia. | ALBUMINOID AMMONIA. |          |            | Chlorine. | Oxygen Consumed. | Fats. | Bacteria per (Cubic Centimeter. |
|----------------------|---------------|---------------------|----------|------------|-----------|------------------|-------|---------------------------------|
|                      |               | Total.              | Soluble. | Insoluble. |           |                  |       |                                 |
| January, . . . . .   | 4.26          | .61                 | .41      | .20        | 9.22      | 3.86             | 4.3   | 2,270,000                       |
| February, . . . . .  | 4.81          | .64                 | .48      | .16        | 8.88      | 4.02             | 6.0   | 1,697,000                       |
| March, . . . . .     | 4.77          | .70                 | .47      | .23        | 13.74     | 5.05             | 2.7   | 1,454,000                       |
| April, . . . . .     | 4.52          | .66                 | .47      | .19        | 13.19     | 3.70             | -     | 1,917,000                       |
| May, . . . . .       | 4.23          | .45                 | .28      | .17        | 12.56     | 2.50             | 2.4   | 1,955,000                       |
| June, . . . . .      | 4.82          | .46                 | .29      | .17        | 17.16     | 2.85             | 1.0   | 1,447,000                       |
| July, . . . . .      | 4.23          | .89                 | .26      | .13        | 14.64     | 2.92             | 4.6   | 1,914,000                       |
| August, . . . . .    | 3.91          | .36                 | .18      | .18        | 12.11     | 2.47             | 1.8   | 1,501,000                       |
| September, . . . . . | 4.71          | .46                 | .22      | .24        | 14.97     | 2.42             | 3.0   | 1,435,000                       |
| October, . . . . .   | 4.98          | .46                 | .28      | .18        | 12.39     | 3.50             | 0.9   | 2,510,000                       |
| November, . . . . .  | 4.08          | .51                 | .33      | .18        | 10.58     | 3.48             | 5.3   | 2,471,000                       |
| December, . . . . .  | 4.31          | .58                 | .33      | .20        | 7.80      | 3.98             | 3.8   | 3,749,000                       |
| Average, . . . . .   | 4.47          | .52                 | .34      | .19        | 12.27     | 3.40             | 3.3   | 2,018,000                       |

*Monthly Averages of Analyses of Supernatant Liquid from Sewage treated with  
Sulphate of Alumina, for Filter No. 19.*

[Parts per 100,000.]

| 1895.                | Free Ammonia. | ALBUMINOID AMMONIA. |          |            | Chlorine. | Oxygen Consumed. | Fats. | Bacteria per (Cubic Centimeter. |
|----------------------|---------------|---------------------|----------|------------|-----------|------------------|-------|---------------------------------|
|                      |               | Total.              | Soluble. | Insoluble. |           |                  |       |                                 |
| January, . . . . .   | 3.77          | .36                 | .26      | .10        | 8.42      | 2.20             | 1.9   | 734,000                         |
| February, . . . . .  | 3.40          | .33                 | .21      | .12        | 10.16     | 2.23             | 1.0   | 245,000                         |
| March, . . . . .     | 4.68          | .50                 | .36      | .14        | 12.89     | 4.23             | 3.9   | 496,000                         |
| April, . . . . .     | 4.20          | .39                 | .27      | .12        | 11.10     | 2.90             | -     | 1,033,000                       |
| May, . . . . .       | 4.02          | .28                 | .19      | .09        | 10.45     | 1.83             | 1.5   | 1,313,000                       |
| June, . . . . .      | 4.63          | .38                 | .20      | .18        | 12.09     | 2.30             | 1.8   | 1,252,000                       |
| July, . . . . .      | 4.23          | .37                 | .23      | .14        | 14.89     | 2.30             | 2.8   | 1,530,000                       |
| August, . . . . .    | 4.65          | .36                 | .21      | .15        | 14.21     | 2.15             | 1.3   | 2,222,000                       |
| September, . . . . . | 5.17          | .42                 | .25      | .17        | 25.48     | 2.65             | 2.5   | 1,583,000                       |
| October, . . . . .   | 4.48          | .33                 | .24      | .09        | 12.80     | 2.70             | 0.7   | 1,380,000                       |
| November, . . . . .  | 3.95          | .36                 | .29      | .07        | 10.44     | 2.28             | 2.8   | 836,000                         |
| December, . . . . .  | 4.27          | .40                 | .27      | .13        | 7.32      | 2.90             | 1.2   | 1,135,000                       |
| Average, . . . . .   | 4.29          | .37                 | .25      | .12        | 12.57     | 2.39             | 1.9   | 1,147,000                       |

*Monthly Averages of Analyses of Sewage strained through Coke, for Filter No. 14 A.*

[Parts per 100,000.]

| 1903.                | Free Ammonia. | ALBUMINOID AMMONIA. |          |            | Chlorine. | Oxygen Consumed. | Fats. | Bacteria per Cubic Centimeter. |
|----------------------|---------------|---------------------|----------|------------|-----------|------------------|-------|--------------------------------|
|                      |               | Total.              | Soluble. | Insoluble. |           |                  |       |                                |
| January, . . . . .   | 4.21          | .48                 | .38      | .15        | 8.65      | 3.06             | -     | 1,344,000                      |
| February, . . . . .  | 4.74          | .53                 | .41      | .12        | 8.34      | 3.40             | 6.0   | 742,000                        |
| March, . . . . .     | 5.54          | .67                 | .47      | .20        | 12.84     | 4.40             | 4.6   | 1,150,000                      |
| April, . . . . .     | 4.40          | .50                 | .34      | .16        | 11.04     | 3.13             | -     | 840,000                        |
| May, . . . . .       | 4.10          | .34                 | .24      | .10        | 12.90     | 2.27             | 2.8   | 1,646,000                      |
| June, . . . . .      | 4.61          | .39                 | .22      | .17        | 21.50     | 2.25             | 1.2   | 888,000                        |
| July, . . . . .      | 4.67          | .39                 | .25      | .14        | 17.86     | 1.96             | 3.0   | 1,160,000                      |
| August, . . . . .    | 4.48          | .30                 | .19      | .11        | 14.35     | 1.83             | 1.5   | 998,000                        |
| September, . . . . . | 5.59          | .42                 | .23      | .19        | 17.99     | 2.65             | 3.3   | 1,999,000                      |
| October, . . . . .   | 4.35          | .62                 | .33      | .19        | 13.55     | 3.10             | 1.0   | 1,822,000                      |
| November, . . . . .  | 4.65          | .55                 | .34      | .21        | 10.45     | 3.03             | 6.6   | 1,383,000                      |
| December, . . . . .  | 4.08          | .33                 | .26      | .12        | 7.62      | 2.43             | 2.3   | 1,554,000                      |
| Average, . . . . .   | 4.62          | .46                 | .30      | .16        | 13.09     | 2.80             | 3.3   | 1,333,000                      |

Summarizing these results, we find that, by allowing the sewage to settle in barrels for four hours and then drawing a sample for analysis from a faucet half-way between the top and bottom of the barrel, this sample shows a removal of 48.0 per cent. of the organic matter (total albuminoid ammonia) and 31.0 per cent. of the bacteria. By this same treatment, together with the addition of sulphate of alumina, a removal of 63.0 per cent. of the organic matter and 61.0 per cent. of the bacteria has been obtained. By straining sewage through a layer of coke, 54.0 per cent. of the organic matter and 54.0 per cent. of the bacteria have been removed from the entire volume of sewage strained.

## COMPARISON OF THE STRENGTH OF STATION SEWAGE.

Bringing together for comparison the average results of analyses of the several series of samples of untreated sewage, we have : —

[Parts per 100,000.]

| 1895.                         | Free Ammonia. | ALBUMINOID AMMONIA. |          |            | Chlorine. | Oxygen Consumed. | Total Nitrogen. |
|-------------------------------|---------------|---------------------|----------|------------|-----------|------------------|-----------------|
|                               |               | Total.              | Soluble. | Insoluble. |           |                  |                 |
| Regular, . . . . .            | 4.05          | 1.00                | .28      | .72        | 11.43     | 5.10             | 4.96            |
| Average, . . . . .            | 4.15          | 0.74                | .33      | .41        | 11.97     | 4.12             | 4.61            |
| For Filter No. 1, . . . . .   | 4.29          | 0.74                | .33*     | .41        | 11.73     | 4.78             | 4.73            |
| For Filter No. 6, . . . . .   | 4.05          | 0.68                | .30*     | .38        | 10.09     | 4.00             | 4.43            |
| For Filter No. 9 A, . . . . . | 4.29          | 0.73                | .33*     | .40        | 9.91      | 3.55             | 4.71            |

\* Estimated.

## COMPOSITION OF SEWAGE.

During 1895, series of samples of sewage from Framingham, Marlborough and the Worcester State Lunatic Hospital have been taken in continuation of the studies of the strength and composition of the sewage applied to different filtration areas in the State. All chemical samples were treated, immediately upon collection, with mercuric acetate in the proportion of 1 part to 4,000, to kill the bacteria and prevent decomposition between the time of collection and of analysis. A separate sample was taken for the immediate determination of the dissolved oxygen present, and still another set of samples was taken, from which plantings for the determination of the number of bacteria present were made. These samples were all taken during cooler weather in 1895 than in 1894, and, consequently, the percentage of dissolved oxygen present was greater.

It will be noticed that all samples were taken at a point where the sewage entered a settling basin. The special features in regard to the places where samples were taken in 1895 were given in the report for 1894, but, for accurate understanding, are repeated.

*Worcester State Lunatic Hospital.* — Situated on the outskirts of the city, and not connected with the city sewers. Practically all the water entering the sewer passes through a meter on the city service pipes. The number of inhabitants on the day when the series was

taken was 980. The samples were collected, as in 1894, at a man-hole several hundred feet from the buildings, and just above the settling tank through which the sewage passes on its way to the irrigating field. The high temperature of the sewage is due to the fact that a considerable portion of the water supply is used for laundry purposes six days in the week. The sewage is very fresh at the point of collection of samples; that is to say, the mixture of organic pollutions and water has very recently taken place, and, owing to this fact, the sewage uniformly contains nitrogen in the form of nitrates and nitrites, and the proportion of free ammonia to organic nitrogen is very low. In fact, the sewage is so fresh that good and representative samples are collected with difficulty, as the floating matters are not well broken up before reaching the point of collection. The measurements of the flow of sewage were taken from the meter readings giving the volume of water used.

*Marlborough.*—The sewerage system of this city is of the so-called separate type; but, as there are no underdrains beneath the sewers, a considerable volume of ground water enters them. The length of the outfall sewer, from the last lateral to the point where it discharges into the settling tank at the filter field, is about four miles.

The following series of samples was taken October 30, at the man-hole just as the sewage enters the settling tank. Measurements of the rate of flow were made by noting the length of time taken to fill one of the compartments of this tank. Free oxygen was present in the sewage during the entire twenty-four hours.

*Framingham.*—The sewerage system is arranged with underdrains beneath the principal sewers to carry off the ground water. The series was collected October 30, at the point where the sewage enters the collecting basin, about one mile from the village. Free oxygen was present in the sewage during the entire twenty-four hours.

In regard to the tables given, it may be said that the samples analyzed were made up of equal portions of sewage taken at the hours enclosed by brackets. The average analysis given in each case is a simple average of the determinations given, and is not, of course, an exact representative analysis of the sewage of the day.

It is proposed during the coming year to take more frequent samples in each series, and that these samples shall be in some measure proportional to the rate of flow of the sewage.

## Results of Analyses of Samples of Sewage collected Hourly from the Main Sewer at the Worcester State Lunatic Hospital.

[Parts per 100,000.]

| Date - 1893.      | Hour.      | Rate of Flow.<br>Gallons<br>passed<br>between<br>Samples. | Temper-<br>ature.<br>—<br>Deg. F. | Bacteria<br>per Cubic<br>Centi-<br>meter. | Per Cent. of Dis-<br>solved Oxygen. | AMMONIA. |                  | Chlorine. | Organic Nitro-<br>gen by Kjeldahl<br>Method. | NITROGEN AS |           | Total<br>Nitrogen.<br>(Organic<br>Nitrogen<br>by<br>Kjeldahl<br>Method) | OXYGEN<br>CONSUMED. |           | Hardness. | Fats. |
|-------------------|------------|-----------------------------------------------------------|-----------------------------------|-------------------------------------------|-------------------------------------|----------|------------------|-----------|----------------------------------------------|-------------|-----------|-------------------------------------------------------------------------|---------------------|-----------|-----------|-------|
|                   |            |                                                           |                                   |                                           |                                     | Free.    | Albu-<br>minoid. |           |                                              | Nitrates.   | Nitrites. |                                                                         | Two Min.            | Five Min. |           |       |
| October 17, . . . | 12.45 P.M. | -                                                         | 74                                | 473,000                                   | 65.1                                | > 0.8000 | .6700            | 3.02      | 1.80                                         | .08         | .0032     | 2.54                                                                    | 5.30                | 10.20     | 7.2       | 4.6   |
| 17, . . .         | 1.45 P.M.  | 1,915                                                     | 70                                | 337,000                                   | 54.4                                |          |                  |           |                                              |             |           |                                                                         |                     |           |           |       |
| 17, . . .         | 2.45 P.M.  | 3,493                                                     | 66                                | 273,000                                   | 67.0                                |          |                  |           |                                              |             |           |                                                                         |                     |           |           |       |
| 17, . . .         | 3.45 P.M.  | 2,394                                                     | 68                                | 525,000                                   | 70.6                                | > 0.8500 | .6400            | 3.99      | 2.89                                         | .09         | .0070     | 3.68                                                                    | 5.00                | 9.70      | 8.2       | 7.7   |
| 17, . . .         | 4.45 P.M.  | 2,693                                                     | 68                                | 525,000                                   | 83.7                                |          |                  |           |                                              |             |           |                                                                         |                     |           |           |       |
| 17, . . .         | 5.45 P.M.  | 3,426                                                     | 64                                | 455,000                                   | 61.0                                |          |                  |           |                                              |             |           |                                                                         |                     |           |           |       |
| 17, . . .         | 6.45 P.M.  | 8,925                                                     | 71                                | 490,000                                   | 56.1                                | > 1.2500 | .7200            | 5.44      | 5.51                                         | .10         | .0022     | 6.64                                                                    | 2.80                | 6.20      | 10.9      | 2.0   |
| 17, . . .         | 7.45 P.M.  | 2,304                                                     | 65                                | 280,000                                   | 77.9                                |          |                  |           |                                              |             |           |                                                                         |                     |           |           |       |
| 17, . . .         | 8.45 P.M.  | 1,795                                                     | 64                                | 175,000                                   | 71.8                                |          |                  |           |                                              |             |           |                                                                         |                     |           |           |       |
| 17, . . .         | 9.45 P.M.  | 1,765                                                     | 64                                | 205,000                                   | 79.1                                | > 0.8500 | .6700            | 3.29      | 2.80                                         | .06         | .0024     | 3.56                                                                    | 7.90                | 11.10     | 10.0      | 5.9   |
| 18, . . .         | 5.15 A.M.  | 9,126                                                     | 63                                | 243,000                                   | 86.6                                |          |                  |           |                                              |             |           |                                                                         |                     |           |           |       |
| 18, . . .         | 6.00 A.M.  | 1,331                                                     | 72                                | 145,000                                   | 69.3                                |          |                  |           |                                              |             |           |                                                                         |                     |           |           |       |
| 18, . . .         | 7.35 A.M.  | 7,570                                                     | 71                                | 413,000                                   | 70.7                                | 0.9875   | .6750            | 3.93      | 3.25                                         | .06         | .0037     | 4.10                                                                    | 5.25                | 9.30      | 9.1       | 5.1   |
| 18, . . .         | 9.00 A.M.  | 18,587                                                    | 75                                | 735,000                                   | 64.6                                |          |                  |           |                                              |             |           |                                                                         |                     |           |           |       |
| 18, . . .         | 10.30 A.M. | 755                                                       | 71                                | 508,000                                   | 70.7                                |          |                  |           |                                              |             |           |                                                                         |                     |           |           |       |
| 18, . . .         | 12.00 M.   | 7,929                                                     | 70                                | 560,000                                   | 70.0                                | 69,603*  |                  |           |                                              |             |           |                                                                         |                     |           |           |       |
| Average, . . .    | .....      |                                                           | 68.5                              | 397,750                                   | 69.3                                |          |                  |           |                                              |             |           |                                                                         |                     |           |           |       |

\* Total flow for twenty-four hours.

## Results of Analyses of Samples of Sewage collected Hourly from the Main Sewer at Marlborough.

[Parts per 100,000.]

| DATE — 1893.      | Hour.      | Rate of Flow, Gallons per 24 Hours. | Temperature, Deg. F. | Bacteria per Cubic Centimeter. | Per Cent of Dissolved Oxygen. | AMMONIA. |             | Chlorine. | Organic Nitrogen by Kjeldahl Method. | NITROGEN AS |           | Total Nitrogen, (Organic Nitrogen by Kjeldahl Method) | OXYGEN CONSUMED. |           | Hardness. | Fats. |
|-------------------|------------|-------------------------------------|----------------------|--------------------------------|-------------------------------|----------|-------------|-----------|--------------------------------------|-------------|-----------|-------------------------------------------------------|------------------|-----------|-----------|-------|
|                   |            |                                     |                      |                                |                               | Free.    | Albuminoid. |           |                                      | Nitrates.   | Nitrites. |                                                       | Two Min.         | Five Min. |           |       |
| October 30, . . . | 11.00 A.M. | 789,600                             | 52                   | 2,520,000                      | 31.5                          | 3.9000   | 1.1700      | 7.79      | 2.85                                 | .11         | .0750     | 6.24                                                  | 4.80             | 7.60      | 19.0      | 5.0   |
| 30, . . .         | 12.00 M.   | 861,322                             | 52                   | 6,900,000                      | 23.9                          |          |             |           |                                      |             |           |                                                       |                  |           |           |       |
| 30, . . .         | 1.00 P.M.  | 823,816                             | 55                   | 2,485,000                      | 19.2                          |          |             |           |                                      |             |           |                                                       |                  |           |           |       |
| 30, . . .         | 2.00 P.M.  | 902,118                             | 52                   | 3,910,000                      | 23.0                          |          |             |           |                                      |             |           |                                                       |                  |           |           |       |
| 30, . . .         | 3.00 P.M.  | 758,016                             | 52                   | 2,588,000                      | 29.5                          | 2.9000   | 0.6700      | 7.41      | 1.53                                 | .15         | .0650     | 4.17                                                  | 3.80             | 5.40      | 16.4      | 4.5   |
| 30, . . .         | 4.00 P.M.  | 789,600                             | 52                   | 1,225,000                      | 32.6                          |          |             |           |                                      |             |           |                                                       |                  |           |           |       |
| 30, . . .         | 5.00 P.M.  | 823,816                             | 52                   | 2,485,000                      | 38.3                          |          |             |           |                                      |             |           |                                                       |                  |           |           |       |
| 30, . . .         | 6.00 P.M.  | 823,816                             | 52                   | 2,750,000                      | 27.4                          | 2.1500   | 0.5300      | 7.29      | 1.35                                 | .19         | .0650     | 3.37                                                  | 3.40             | 5.10      | 14.8      | 3.0   |
| 30, . . .         | 7.00 P.M.  | 823,816                             | 52                   | 1,960,000                      | 30.3                          |          |             |           |                                      |             |           |                                                       |                  |           |           |       |
| 30, . . .         | 8.00 P.M.  | 676,424                             | 52                   | 1,008,000                      | 32.6                          |          |             |           |                                      |             |           |                                                       |                  |           |           |       |
| 30, . . .         | 9.00 P.M.  | 728,406                             | 52                   | 595,000                        | 27.0                          | 1.9500   | 0.3100      | 8.58      | 0.98                                 | .14         | .0660     | 2.77                                                  | 1.70             | 2.70      | 13.8      | 1.7   |
| 30, . . .         | 10.00 P.M. | 701,428                             | 52                   | 928,000                        | 39.3                          |          |             |           |                                      |             |           |                                                       |                  |           |           |       |
| 31, . . .         | 5.15 A.M.  | 592,200                             | 51                   | 525,000                        | 70.9                          |          |             |           |                                      |             |           |                                                       |                  |           |           |       |
| 31, . . .         | 6.00 A.M.  | 592,200                             | 51                   | 595,000                        | 75.3                          | 1.0100   | 0.2300      | 4.91      | 0.33                                 | .39         | .0300     | 1.58                                                  | 0.24             | 0.40      | 6.0       | 0.8   |
| 31, . . .         | 7.00 A.M.  | 592,200                             | 51                   | 525,000                        | 81.9                          |          |             |           |                                      |             |           |                                                       |                  |           |           |       |
| 31, . . .         | 8.00 A.M.  | 573,776                             | 51                   | 525,000                        | 90.3                          |          |             |           |                                      |             |           |                                                       |                  |           |           |       |
| 31, . . .         | 9.00 A.M.  | 701,428                             | 52                   | 1,470,000                      | 85.3                          | 2.2500   | 0.4300      | 4.39      | 0.48                                 | .33         | .0300     | 2.69                                                  | 0.36             | 0.64      | 8.2       | 1.3   |
| 31, . . .         | 10.00 A.M. | 728,408                             | 52                   | 1,890,000                      | 55.5                          |          |             |           |                                      |             |           |                                                       |                  |           |           |       |
| Average, . . .    | .....      | 737,910                             | 51.9                 | 1,938,000                      | 43.2                          | 2.3600   | 0.5600      | 6.73      | 1.26                                 | .22         | .0626     | 3.47                                                  | 2.38             | 3.62      | 13.0      | 2.7   |



## Results of Analyses of Samples of Sewage collected Hourly from the Main Sewer at Frammingham.

[Parts per 100,000.]

| DATE - 1895.      | Hour.      | Rate of Flow.<br>Gallons passed between Samples. | Temper-<br>ature.<br>Deg. F. | Bacteria<br>per Cubic<br>Centi-<br>meter. | Per Cent. of Dis-<br>solved Oxygen. | AMMONIA.      |                  | Chlorine. | Organic Nitro-<br>gen by Kjeldahl<br>Method. | NITROGEN AS |           | OXYGEN<br>CONSUMED. |           | Hardness. | Fats. |
|-------------------|------------|--------------------------------------------------|------------------------------|-------------------------------------------|-------------------------------------|---------------|------------------|-----------|----------------------------------------------|-------------|-----------|---------------------|-----------|-----------|-------|
|                   |            |                                                  |                              |                                           |                                     | Free.         | Albu-<br>minoid. |           |                                              | Nitrates.   | Nitrates. | Two Min.            | Five Min. |           |       |
| October 30, . . . | 11.00 A.M. | -                                                | 55                           | 1,015,000                                 | 19.9                                | { 2.8500 }    | .7000            | 8.01      | 2.02                                         | .17         | .0340     | 4.20                | 7.00      | 15.0      | 9.1   |
| 30, . . .         | 12.00 M.   | 8,058                                            | 56                           | 875,000                                   | 20.0                                |               |                  |           |                                              |             |           |                     |           |           |       |
| 30, . . .         | 1.00 P.M.  | 21,218                                           | 56                           | 1,165,000                                 | 23.0                                | { 2.2500 }    | .6200            | 8.31      | 1.58                                         | .13         | .0200     | 4.20                | 8.00      | 19.6      | 9.7   |
| 30, . . .         | 2.00 P.M.  | 10,636                                           | 55                           | 1,225,000                                 | 24.6                                |               |                  |           |                                              |             |           |                     |           |           |       |
| 30, . . .         | 3.00 P.M.  | 19,064                                           | 55                           | 2,415,000                                 | 24.8                                | { 1.8500 }    | .4700            | 6.64      | 1.17                                         | .13         | .0300     | 2.20                | 4.40      | 11.8      | 2.4   |
| 30, . . .         | 4.00 P.M.  | 15,887                                           | 55                           | 2,065,000                                 | 18.4                                |               |                  |           |                                              |             |           |                     |           |           |       |
| 30, . . .         | 5.00 P.M.  | 13,055                                           | 55                           | 1,785,000                                 | 25.3                                | { 1.7500 }    | .4800            | 6.91      | 1.30                                         | .12         | .0300     | 3.00                | 4.50      | 15.0      | 5.0   |
| 30, . . .         | 6.00 P.M.  | 11,472                                           | 54                           | 210,000                                   | 33.0                                |               |                  |           |                                              |             |           |                     |           |           |       |
| 30, . . .         | 7.00 P.M.  | 13,110                                           | 53                           | 490,000                                   | 27.7                                | { 0.4500 }    | .1100            | 5.12      | 0.30                                         | .19         | .0200     | 0.80                | 0.90      | 9.4       | 1.2   |
| 30, . . .         | 8.00 P.M.  | 14,181                                           | 53                           | 1,085,000                                 | 26.7                                |               |                  |           |                                              |             |           |                     |           |           |       |
| 30, . . .         | 9.00 P.M.  | 10,299                                           | 53                           | 2,785,000                                 | 13.1                                | { 2.3500 }    | .6800            | 6.55      | 2.31                                         | .15         | .0360     | 2.60                | 5.30      | 10.8      | 4.9   |
| 30, . . .         | 10.00 P.M. | 10,269                                           | 53                           | 876,000                                   | 30.0                                |               |                  |           |                                              |             |           |                     |           |           |       |
| 31, . . .         | 5.00 A.M.  | 64,467                                           | 53                           | 1,785,000                                 | 43.4                                | { 1.9200 }    | .6300            | 7.01      | 1.43                                         | .16         | .0283     | 2.83                | 6.16      | 13.6      | 5.5   |
| 31, . . .         | 6.00 A.M.  | 9,500                                            | 54                           | 2,730,000                                 | 38.5                                |               |                  |           |                                              |             |           |                     |           |           |       |
| 31, . . .         | 7.00 A.M.  | 5,500                                            | 54                           | 420,000                                   | 44.8                                | { 1.325,888 } | 276,325*         | 54.3      | 27.8                                         | 54.3        | 27.8      | 54.3                | 27.8      | 54.3      | 27.8  |
| 31, . . .         | 8.00 A.M.  | 18,151                                           | 55                           | 910,000                                   | 30.4                                |               |                  |           |                                              |             |           |                     |           |           |       |
| 31, . . .         | 9.00 A.M.  | 14,016                                           | 54                           | 1,436,000                                 | 29.6                                | { 1.325,888 } | 276,325*         | 54.3      | 27.8                                         | 54.3        | 27.8      | 54.3                | 27.8      | 54.3      | 27.8  |
| 31, . . .         | 10.00 A.M. | 17,472                                           | 54                           | 595,000                                   | 22.9                                |               |                  |           |                                              |             |           |                     |           |           |       |
| Average, . . .    | .....      | 276,325*                                         | 54.3                         | 1,325,888                                 | 27.8                                | 1.9200        | .6300            | 7.01      | 1.43                                         | .16         | .0283     | 2.83                | 6.16      | 13.6      | 5.5   |

\* Total flow for twenty-four hours.

*Table showing Comparison of Relative Amounts of Different Substances in Representative Sewage from the Several Places Aforesaid.*

*Nitrogen as Albuminoid Ammonia (Wanklyn), with Organic Nitrogen (Kjeldahl).*

[Parts per 100,000.]

|                                                        | Worcester<br>State<br>Lunatic<br>Hospital. | Marl-<br>borough. | Framing-<br>ham. | Lawrence<br>Street<br>Sewer. | Experiment<br>Station. |
|--------------------------------------------------------|--------------------------------------------|-------------------|------------------|------------------------------|------------------------|
| Nitrogen as albuminoid ammonia<br>(Wanklyn), . . . . . | 0.55                                       | 0.50              | 0.43             | 0.53                         | 0.61                   |
| Organic nitrogen (Kjeldahl), . . . . .                 | 3.25                                       | 1.26              | 1.45             | 2.16                         | 1.58                   |
| Per cent. which former is of latter, . . . . .         | 17                                         | 39                | 30               | 25                           | 38                     |
| Per cent. of dissolved oxygen, . . . . .               | 69                                         | 45                | 28               | 63                           | 0                      |

*Nitrogen as Free Ammonia, with Total Nitrogen (Kjeldahl).*

|                                                |      |      |      |      |      |
|------------------------------------------------|------|------|------|------|------|
| Nitrogen as free ammonia, . . . . .            | 0.77 | 1.94 | 1.57 | 1.35 | 2.81 |
| Total nitrogen (Kjeldahl), . . . . .           | 4.10 | 3.47 | 3.19 | 3.80 | 4.39 |
| Per cent. which former is of latter, . . . . . | 19   | 56   | 49   | 36   | 64   |

*Oxygen consumed, determined after boiling Two Minutes and Five Minutes.*

|                                                |      |      |      |      |   |
|------------------------------------------------|------|------|------|------|---|
| Oxygen consumed after two minutes, . . . . .   | 5.25 | 2.38 | 2.83 | 4.24 | - |
| Oxygen consumed after five minutes, . . . . .  | 9.30 | 3.62 | 5.16 | 7.05 | - |
| Per cent. which former is of latter, . . . . . | 56   | 66   | 55   | 60   | - |

*Total Nitrogen (Kjeldahl), with Oxygen consumed after Two Minutes.*

|                                                |      |      |      |      |      |
|------------------------------------------------|------|------|------|------|------|
| Total nitrogen (Kjeldahl), . . . . .           | 4.10 | 3.47 | 3.19 | 3.80 | 4.39 |
| Oxygen consumed after two minutes, . . . . .   | 5.25 | 2.38 | 2.83 | 4.24 | 5.22 |
| Per cent. which former is of latter, . . . . . | 78   | 145  | 112  | 89   | 84   |

*Total Nitrogen (Kjeldahl), with Chlorine.*

|                                                |      |      |      |      |      |
|------------------------------------------------|------|------|------|------|------|
| Total nitrogen (Kjeldahl), . . . . .           | 4.10 | 3.47 | 3.19 | 3.80 | 4.39 |
| Chlorine, . . . . .                            | 3.93 | 6.73 | 7.01 | 5.79 | 9.17 |
| Per cent. which former is of latter, . . . . . | 104  | 51   | 45   | 65   | 47   |

*Total Nitrogen (Kjeldahl), with Fats.*

|                                                |      |      |      |      |      |
|------------------------------------------------|------|------|------|------|------|
| Total nitrogen (Kjeldahl), . . . . .           | 4.10 | 3.47 | 3.19 | 3.80 | 4.39 |
| Fats, . . . . .                                | 5.1  | 2.7  | 5.5  | -    | -    |
| Per cent. which former is of latter, . . . . . | 80   | 128  | 58   | -    | -    |

This last table shows the relative amounts of the different substances in the average sewage of each place. The average analysis of the Worcester Hospital sewage agrees very closely with the average analysis of the 1894 series. The number of inhabitants of the institution and the total flow of sewage for the day are also nearly identical for both years. With the Marlborough and Framingham sewages the amounts of these various substances are less in almost every instance in 1895 than they were in 1894. This difference is due to the fact that the total daily flow of sewage was greater on the day on which the series were taken in 1895 than it was in 1894. That is to say, the sewage, especially at Marlborough, was diluted by a much larger volume of ground water, owing to recent rains.

The chief points of the analyses to be noticed are that, as in 1894, the amount of organic nitrogen represented by the albuminoid ammonia is a comparatively small and variable per cent. of that found by the Kjeldahl method. This percentage is lowest where the sewage is freshest and the amount of dissolved oxygen highest; where the sewage is most stale, that is, where it has undergone the longest-continued chemical and bacterial action, the percentage is greatest. The percentage which the nitrogen, as free ammonia, forms of the total nitrogen, follows the same general rule.

#### PERMANENCY OF SEWAGE FILTERS.

The permanency of a sewage filter depends upon the maintenance of an equality between the amount of organic matter applied to the filter, and the amount purified and removed in the effluent or escaping into the air in the form of gas, plus the amount removed from the surface of the filter. If a limited area for filtration purposes is a necessity, there is of course more or less accumulation of organic matters upon the surface of the filter or within the upper few inches of the filtering material.

If the sewage is fresh when it flows upon the filter, the organic matter in suspension will not be finely divided and hence will strain out, remain upon the surface of the filter, and can be removed without removing much if any of the filtering material. This removal keeps the filter porous, in good condition, and the dry scum removed decomposes so slowly that it does not create a nuisance. On the other hand, if the sewage is stale when it flows upon the filtering

area, and the sludge or organic matter in suspension is finely divided by the comparatively long-continued mechanical, chemical and bacterial actions through which it has passed, a much larger percentage of this organic matter will pass into the interstices of the filtering material, and, if removed in any way except by being changed into the inorganic form and passing away in the effluent or escaping into the air in the form of nitrogen and carbon gases, a considerable portion of the surface layers of the filtering material will have to be removed also.

During the earlier years of the investigations at this station the sewage applied to the filters was comparatively weak, but fresh; and considerable trouble was experienced, caused by the clogging of the surface of the filters by the crude organic matters of the sewage; and comparatively poor purification was obtained at such times, because of the difficulty with which the sewage passed through these clogged surfaces, and also because of insufficient aëration from the same cause. During latter years the sewage applied to the filters has been stale, and, because of this and the consequent fine division of the sludge, there has not been so much clogging of the surface as formerly, and very little difficulty has been experienced in disposing of the prescribed daily dose of sewage. The sewage applied to the experimental filters contained, on an average, twice as much unoxidized nitrogen during 1895 as during most of the earlier years (see page 446), and hence, although the number of gallons per acre daily applied to the out-door filters has been largely reduced in some instances, the amount of organic matter applied has not been reduced much, if any. This stale organic matter has apparently been worked over to such an extent, during its slow passage through the pipe from the sewer to the station, that it is of a nature more easily attacked by the bacteria in the filter than was the former fresh organic matter. As a result of this, there has not been the steady increase of stored nitrogen and fats in the filters that formerly occurred. The amount of this stored nitrogen present fluctuates according to seasons of high or low nitrification.

*Table showing the Amount of Nitrogen stored in the Sand of Filters Nos 1 and 9 A at Different Periods, calculated from Determinations of Albuminoid Ammonia.*

[Parts per 100,000 by weight of dry sand.]

| DEPTH BELOW SURFACE.<br>(INCHES.) | FILTER NO. 1.  |                |                |                 | FILTER NO. 9 A. |                |                |
|-----------------------------------|----------------|----------------|----------------|-----------------|-----------------|----------------|----------------|
|                                   | Jan.,<br>1894. | Oct.,<br>1894. | Oct.,<br>1895. | March,<br>1896. | Jan.,<br>1894.  | Nov.,<br>1894. | Oct.,<br>1895. |
| 16, . . . . .                     | 17.5           | 11.5           | 37.6           | 27.6            | 33.1            | 23.5           | 47.2           |
| 9, . . . . .                      | 17.7           | 13.9           | 24.4           | 20.0            | 16.5            | 22.9           | 9.2            |
| 12, . . . . .                     | 21.5           | 15.0           | 13.2           | 16.0            | 11.3            | 11.6           | 7.6            |
| 18, . . . . .                     | 21.0           | 13.8           | 8.6            | 10.0            | 8.3             | 8.0            | 6.0            |
| 24, . . . . .                     | 17.2           | 11.8           | 6.6            | 8.9             | 3.8             | 6.0            | 3.6            |
| 36, . . . . .                     | 5.9            | 4.9            | 3.6            | 5.9             | 2.6             | 4.0            | 2.4            |
| 48, . . . . .                     | 4.3            | 2.5            | 3.0            | 3.8             | 2.6             | 3.0            | 2.4            |
| 60, . . . . .                     | 3.0            | 1.8            | 2.0            | 3.4             | 1.8             | 1.8            | 2.4            |

In this table the amount of nitrogen in the upper six inches of filtering material is not given, as the method of spading over the surface of the filters to this depth at least twice each year makes accurate and representative determinations difficult to obtain; but the analyses made of the sand of this portion of the filters indicated that there was a smaller amount of stored nitrogen in the upper six inches of Filter No. 1 in October, 1895, than in October, 1894, and that the stored nitrogen in the upper six inches of Filter No. 9 A had increased but little, if any.

There has been no removal of clogged sand from any of the large outdoor filters at the station since 1893 (see pages 413 and 414 of report of 1893), and the weekly rakings to the depth of one inch, together with the spading over of the surface spring and fall, keep the filters in such condition that little difficulty is experienced from the inability of the applied sewage to pass below the surface of the filter.

The actual number of gallons of sewage applied to the large filters, one two-hundredth of an acre in area, from their date of construction up to Jan. 1, 1896, is given in the following table:—

| FILTER NUMBER. | Date when Sewage was First Applied. | Actual Number of Gallons Applied. | Gallons per Acre. |
|----------------|-------------------------------------|-----------------------------------|-------------------|
| 1, . . . . .   | Jan. 10, 1888, . . . . .            | 1,077,000                         | 215,400,000       |
| 2, . . . . .   | Dec. 19, 1887, . . . . .            | 499,300                           | 99,860,000        |
| 4, . . . . .   | Dec. 19, 1887, . . . . .            | 362,400                           | 72,480,000        |
| 5, . . . . .   | Sept. 14, 1891, . . . . .           | 665,400                           | 121,080,000       |
| 6, . . . . .   | Jan. 12, 1888, . . . . .            | 664,000                           | 132,800,000       |
| 9 A, . . . . . | Nov. 18, 1890, . . . . .            | 663,700                           | 132,740,000       |

### RESTING.

With the idea of securing the removal of nitrogen from the surface layers of the large outdoor filters, they were allowed to rest during a large portion of the months of October and November, 1894. The weather was very cold for these months, and this prolonged resting resulted in destroying active nitrification in these filters, and as a result the purification obtained by them during the ensuing winter was very poor. Profiting by this experience, the filters were allowed to rest for short periods only, and during warmer weather in October and November, 1895.

It is very doubtful if any resting, except during warm weather, when nitrification is active, is effective in removing nitrogen, but it gives the filter a chance to drain and the top layers of material to dry.

### EFFECT OF WINTER WEATHER.

The first effect of winter weather is the diminution of the activity of the nitrifying organism. This causes the nitrates of the effluent to become low and increases the quantity of free and albuminoid ammonia. If the sewage applied to the filters does not contain an excessive amount of sludge, or organic matters in suspension, it can be applied in such volume as to keep the filter comparatively free from frost; when sludge is present in large quantity, however, a large volume of sewage will tend to clog the surface of the filter by the deposition of this sludge upon the surface. With the concentrated sewage now pumped at the station, a sewage much stronger than the average of the twenty-four hours' flow in the Lawrence Street sewer, this difficulty is quite a factor in the management of the filters. Where settling basins and sludge beds are in operation this difficulty can be, in a measure, overcome.

### AVERAGE PURIFICATION OF SEWAGE BY THE SEVERAL FILTERS IN 1895.

The following table gives the average results obtained by the several filters during 1895. The qualitative efficiency of the filters is shown by the percentage removal of organic matter of the applied sewage, as indicated by the albuminoid ammonia and oxygen consumed:—

*Average Per Cent. of Albuminoid Ammonia, Oxygen consumed and of Bacteria removed from Sewage by the Several Filters, with Average Rates of Filtration, 1895.*

|       | NUMBER OF FILTER. |   |   | Depth of Sand<br>(Inches). | Mean Diameter<br>(Inches). | Area in Fractions<br>of an Acre. | SIZE OF SAND.                                                         |                           | Manner of Filling. | In Operation<br>Since | Average Rate of<br>Filtration (Gal-<br>lons per Acre)<br>Daily. | AVERAGE PER CENT. REMOVED OF |                     |           |
|-------|-------------------|---|---|----------------------------|----------------------------|----------------------------------|-----------------------------------------------------------------------|---------------------------|--------------------|-----------------------|-----------------------------------------------------------------|------------------------------|---------------------|-----------|
|       |                   |   |   |                            |                            |                                  | Effective Size<br>in Millime-<br>ters (10 Per<br>Cent. Finer<br>than) | Uniformity<br>Coefficient |                    |                       |                                                                 | Albuminoid<br>Ammonia.       | Oxygen<br>Consumed. | Bacteria. |
| 1,    | .                 | . | . | 63                         | 200                        | $\frac{1}{16}$                   | 0.48                                                                  | 2.4                       | Wet.               | Jan. 10, 1888.        | 67,000                                                          | 89                           | 86                  | 97.55     |
| 2,    | .                 | . | . | 60                         | 200                        | $\frac{1}{16}$                   | 0.08                                                                  | 2.0                       | Wet.               | Dec. 19, 1887.        | 34,000                                                          | 97                           | 95                  | 99.98     |
| 4,    | .                 | . | . | 60                         | 200                        | $\frac{1}{16}$                   | 0.04                                                                  | 2.7                       | Wet.               | Dec. 19, 1887.        | 15,000                                                          | 98                           | 96                  | 99.99     |
| 5 A,  | .                 | . | . | 63                         | 200                        | $\frac{1}{16}$                   | 1.40                                                                  | 2.4                       | Dry.               | Sept. 14, 1891.       | 66,000                                                          | 85                           | 83                  | 94.50     |
| 6,    | .                 | . | . | 44                         | 200                        | $\frac{1}{16}$                   | 0.35                                                                  | 7.8                       | Wet.               | Jan. 12, 1888.        | 56,000                                                          | 90                           | 89                  | 99.10     |
| 9 A,  | .                 | . | . | 60                         | 200                        | $\frac{1}{16}$                   | 0.17                                                                  | 2.0                       | Dry.               | Nov. 18, 1890.        | 66,000                                                          | 90                           | 89                  | 98.70     |
| 10,   | .                 | . | . | 60                         | 200                        | $\frac{1}{16}$                   | 0.35                                                                  | 7.8                       | Dry.               | July 16, 1894.        | 30,000                                                          | 94                           | 90                  | 96.50     |
| 15 B, | .                 | . | . | 65                         | 20                         | $\frac{1}{16}$                   | 5.10                                                                  | 2.0                       | Dry.               | July 25, 1892.        | 440,000                                                         | 83                           | 76                  | 89.00     |
| 16 B, | .                 | . | . | 65                         | 20                         | $\frac{1}{16}$                   | 5.10                                                                  | 2.0                       | Dry.               | July 25, 1892.        | 465,000                                                         | 85                           | 80                  | 84.00     |
| 21 A, | .                 | . | . | 60                         | 20                         | $\frac{1}{16}$                   | 1.60                                                                  | 2.4                       | Dry.               | March 19, 1894.       | 340,000                                                         | 87                           | 83                  | 92.30     |
| 22 A, | .                 | . | . | 60                         | 20                         | $\frac{1}{16}$                   | Coke.                                                                 | -                         | Dry.               | March 19, 1894.       | 336,000                                                         | 91                           | 90                  | 94.50     |
| 51,   | .                 | . | . | 60                         | 50                         | $\frac{1}{16}$                   | 5.30                                                                  | 2.4                       | Dry.               | Feb. 1, 1895.         | 608,000                                                         | 63                           | 58                  | 77.00     |
| 52,   | .                 | . | . | 60                         | 50                         | $\frac{1}{16}$                   | Coke.                                                                 | -                         | Dry.               | Feb. 1, 1895.         | 608,000                                                         | 74                           | 67                  | 83.50     |
| 59,   | .                 | . | . | 60                         | 30                         | $\frac{1}{16}$                   | 2.50                                                                  | 2.0                       | Dry.               | April 1, 1895.        | 520,000                                                         | 75                           | 70                  | 77.00     |

## REMOVAL OF SLUDGE FROM THE SEWAGE.

As the experiments have continued with the consequent accumulation of data concerning the strength and composition of sewage, it has become evident that the sewage pumped at the station and applied to the experimental filters has been stronger during 1895 than the average sewage flowing through the Lawrence Street sewer, and stronger than any sewage treated at the filtration areas at different places in the State. As a matter of fact, the sludge is generally settled out to a considerable extent at the filtration areas, and applied to separate beds. This method has its advantages, as it concentrates the sludge, and keeps a large amount of clogging material from flowing upon the regular filtration beds. This is especially advantageous in winter, as has been mentioned before. Its disadvantages are, that the sludge, so concentrated, is much more offensive than when allowed to flow upon the filtration areas as rapidly as possible, and become exposed in thin layers to the air. In cold weather, however, the accumulation of sludge is less offensive than in warm weather. Studies of different methods of removing sludge from sewage have been continued throughout the year, as follows : —

1. Rapid filtration through coarse gravel, with the aid of a current of air drawn down through the gravel.
2. Rapid filtration through coarse gravel, with the aid of a current of air forced up through the gravel.
3. Rapid filtration through medium coarse coke, with a current of air forced up through the coke.
4. Sedimentation.
5. Chemical precipitation.
6. Straining through coke.

The percentage removal of organic matter, as indicated by the albuminoid ammonia and the oxygen consumed, and of the bacteria, is shown by the following table : —



*Table showing Purification of Sewage by Different Methods of removing Sludge.*

| METHOD.                                                                                                 | Number of Filter. | Effective Size of Sand. | Uniformity Coefficient. | In Operation since | PERCENTAGE REMOVED OF |                  |           |
|---------------------------------------------------------------------------------------------------------|-------------------|-------------------------|-------------------------|--------------------|-----------------------|------------------|-----------|
|                                                                                                         |                   |                         |                         |                    | Albuminoid Ammonia.   | Oxygen Consumed. | Bacteria. |
| Rapid filtration through coarse gravel, with the aid of a current of air drawn down through the gravel. | 15                | 5.40                    | 2.0                     | July 25, 1892.     | 83                    | 76               | 89        |
|                                                                                                         | 16                | 5.40                    | 2.0                     | July 25, 1892.     | 85                    | 80               | 84        |
|                                                                                                         | 21                | 1.00                    | 2.4                     | March 19, 1894.    | 87                    | 83               | 92        |
|                                                                                                         | 39                | 2.50                    | 2.0                     | April 1, 1895.     | 75                    | 70               | 77        |
| Rapid filtration through coarse gravel, with the aid of a current of air forced up through the gravel.  | 51                | 5.30                    | 2.4                     | Feb. 1, 1895.      | 63                    | 52               | 77        |
| Rapid filtration through medium coarse coke, with a current of air forced up through the coke.          | 52                | Coke                    | -                       | Feb. 1, 1895.      | 74                    | 67               | 83        |
| Sedimentation, . . . . .                                                                                | -                 | -                       | -                       | -                  | 48                    | 34               | 31        |
| Chemical precipitation, . . . . .                                                                       | -                 | -                       | -                       | -                  | 63                    | 53               | 61        |
| Straining through coke, . . . . .                                                                       | -                 | -                       | -                       | -                  | 54                    | 45               | 54        |

### COMPARISON OF THE SEVERAL METHODS.

The first method mentioned has been under investigation at the station for several years, and has been exhaustively discussed in the reports of the Board. It is a scientific success, and perhaps, under favorable conditions, could be used practically. The method of aerating the filters at the station is exceedingly costly, as compared with the results secured. The aspirators attached to filters Nos. 15 and 16 are operated with the entire head or pressure of the city water supply, and will, when attached to a tube of mercury, draw the mercury to a height that shows their power to produce very nearly a vacuum. This gives a power sufficient to draw air through the filters of coarse gravel, even when they are very badly clogged with organic matter. These two filters have received sewage at an average rate of about 450,000 gallons per acre daily, and have removed from it the very large percentage of organic matter shown by the table. This organic matter has been largely oxidized or burned up, but not by any means completely, over 20 per cent. of that applied during 1895 being stored in each filter. This storage of organic matter causes sooner or later such a clogging of the filter and poor purification that it must be removed, or the life of the

filter is ended. Removal by continuous aëration without application of sewage to the filter is a slow and incomplete method, and, if the gravel be removed and washed, the labor is considerable and the volume of water used very large.

*Forcing Air up through the Filter.*

On Feb. 1, 1895, an experiment was begun to test the value, estimated by percentage removal of sludge, of filtering sewage through some coarse media at high rates, aided by a current of air forced up through the filtering material.

For this purpose two filters of equal size were constructed, one containing 60 inches in depth of coarse gravel of an effective size of 5.30 millimeters, and the other with the same depth of coke breeze, from which the finer particles had been removed. The outlets of these filters were trapped, and down through the centre of each a pipe was passed, reaching to within 6 inches of the bottom of the filter. To these pipes a fan blower was attached, driven by electric power, the idea being to carry the air to the under-drains of each filter, where it would pass out into the under-drains and be forced up through the interstices of the filtering material. These filters have received sewage at an average rate, during their period of operation, of 608,000 gallons per acre daily. The blowing apparatus used created a current of air that was capable, under the most favorable circumstances and with the fan making 3,600 revolutions per minute, of holding up a column of mercury nearly 3 inches. With the connections and elbow joints necessary to carry the air to the point desired, the force of the current was reduced to one-third of this. During the period of operation of these filters this current of air was never strong enough to move pieces of paper laid upon the surface of the filters, and was only occasionally strong enough to be felt by placing the hand upon the surface. When the surface became badly clogged, the force of the current generated by the open-sided blower was apparently only strong enough to keep a steady pressure of air against the under side of the clogged surface layers of the filter, and there was a constant current of air from the open sides of the blower. The filters used in this experiment were numbered 51 and 52.

*Filter No. 51.*—This filter, one three-thousandth of an acre in area, contained 60 inches in depth of gravel of an effective size of

5.30 millimeters. It received sewage during the period of its operation at an average rate of 608,400 gallons per acre daily, and its effluent contained on an average 37 per cent. of the organic matter of the applied sewage, as shown by the albuminoid ammonia determinations, and 23 per cent., as shown by the determinations of oxygen consumed. Two and eighty-one one-hundredths pounds of organic nitrogen were applied to the filter, 1.15 pounds of organic nitrogen passed away in the effluent, and 0.27 of a pound remained stored in the filter at the close of the experiment. (For details of operation, see page 491.)

*Filter No. 52.*—This filter was of the same depth and area as Filter No. 51, but contained, instead of gravel, coke breeze from which the finer particles had been removed. It was operated in the same manner as Filter No. 51, and received during its period of operation the same volume of sewage. It was a more efficient filter in removing organic nitrogen from the applied sewage than Filter No. 51, but this nitrogen was stored in the filter, as shown by the fact that nitrification was lower than in Filter No. 51. This removal of sludge from the applied sewage was aided by the exceedingly rough surfaces of the pieces of coke.

*Disposal of Effluents of Filters Nos. 51 and 52.*—The effluents of filters Nos. 51 and 52 were, for the comparison of results obtained, each divided into three portions, and applied equally to filters of equal depth and area, but containing different filtering materials; that is, the effluent of Filter No. 51 was applied to Filter No. 53, one twenty-thousandth of an acre in area and containing 60 inches in depth of sand of an effective size of 0.19 millimeter; to Filter No. 55, of the same area and depth, but containing sand of an effective size of 0.40 millimeter; and to Filter No. 57, containing 60 inches in depth of coke breeze. The effluent of Filter No. 52 was applied to three similar filters, — filters Nos. 54, 56 and 58.

The results obtained by this double filtration were not as good as the results obtained by the filters 15 B, 16 B, 12 A combination, as shown by the next table, owing to the comparatively poor purification obtained in filters Nos. 51 and 52. There was no appreciable difference in the operation of these filters, and the qualitative results obtained were very similar, as shown by the table.

The amount of nitrogen stored in the sand filters at the close of the experiment, calculated from albuminoid ammonia determinations, was as follows:—

[Parts per 100,000 by weight of dry sand.]

| DEPTH BELOW SURFACE (INCHES). | Filter No. 53.           | Filter No. 55.           | Filter No. 54.           | Filter No. 56.           |
|-------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
|                               | Effective Size,<br>0.19. | Effective Size,<br>0.40. | Effective Size,<br>0.19. | Effective Size,<br>0.40. |
| 0-6, . . . . .                | 72.7                     | 58.4                     | 76.1                     | 58.9                     |
| 9, . . . . .                  | 14.9                     | 20.7                     | 24.4                     | 17.9                     |
| 12, . . . . .                 | 9.2                      | 12.0                     | 10.8                     | 13.9                     |
| 18, . . . . .                 | 5.9                      | 7.4                      | 9.8                      | 8.5                      |
| 24, . . . . .                 | 6.1                      | 4.9                      | 4.9                      | 5.6                      |
| 36, . . . . .                 | 3.6                      | 4.0                      | 5.0                      | 3.9                      |
| 48, . . . . .                 | 3.1                      | 4.3                      | 2.6                      | 3.4                      |
| 60, . . . . .                 | 2.0                      | 4.3                      | 2.0                      | 3.1                      |

*Sedimentation.*

At many sewage disposal areas the sewage is allowed to pass through settling tanks, in order that as large an amount of the sludge as possible may settle out; the supernatant liquor then flows to the disposal areas and the sludge to specially prepared sludge beds. The amount of sludge removed by this method varies with the character and strength of the sewage.

During 1892 the continuous experiment at the station showed a removal of 18 per cent., and during 1895 of 48 per cent., of sludge, as indicated by the total albuminoid ammonia. The sewage of the latter year contained much more sludge than the sewage of the former year. A larger percentage of the sludge can generally be removed from fresh sewage than from stale sewage in which the sludge is more finely divided. (For results upon the removal of sludge, see pages 450 and 451.)

*Chemical Precipitation.*

The percentage removal of sludge by means of the addition of chemicals to the sewage, and subsequent sedimentation, depends upon the same factors as in the removal of sludge by sedimentation alone. In both cases the result is a concentration of the sludge in a smaller body of liquid. This resulting concentrated sewage, in volume generally at least one-fourth the original volume, remains to be disposed of. (For results upon chemical precipitation, see pages 450 and 451.)

*Straining through Coke.*

By straining sewage through coke we have removed, during 1895, 54 per cent. of the sludge (total albuminoid ammonia) of the sewage. The sewage has been strained at an average rate of 1,000,000 gallons per acre daily, and the coke strainer has contained from 6 to 8 inches in depth of coke. The coke used is known as breeze, and is the screenings from commercial coke. At the Lawrence gas house, where it is obtained, it is used under the boilers, and called worth one-fourth as much as the steam coal or from \$1.00 to \$1.25 per ton; the amount used has been equal to 10 cubic yards per 1,000,000 gallons of sewage strained, and, as a ton of coke contains about 2.3 cubic yards, the sewage has been purified, to the extent given, at a cost for coke of \$5.43 per 1,000,000 gallons of sewage strained, calling the coke worth \$1.25 per ton.

By this method of straining we remove the sludge from the entire body of liquid, and get rid of the concentrated sludge liquor which is a result of sedimentation and chemical precipitation; and it seems probable that the coke is as valuable for combustion after use in the strainer as before.

The following table shows the qualitative and quantitative purification obtained by these different methods for removing sludge, followed by filtration, during 1895:—

*Table showing Total Purification of Sewage by Filtration and a Preliminary Treatment to remove Sludge.*

| METHOD.                                                                                                                | Number of Filter. | SIZE OF SAND.                                          |                         | Average Rate (Gallons per Acre Daily, Six Days a Week). | PERCENTAGE REMOVED OF |                  |           |
|------------------------------------------------------------------------------------------------------------------------|-------------------|--------------------------------------------------------|-------------------------|---------------------------------------------------------|-----------------------|------------------|-----------|
|                                                                                                                        |                   | Effective Size in Millimeters Ten Per Cent. finer than | Uniformity Coefficient. |                                                         | Albuminoid Ammonia.   | Oxygen Consumed. | Bacteria. |
| By rapid filtration through gravel, aided by a current of air and filtration through sand (filters No. 15 and No. 16). | 12 A              | .19                                                    | 2.0                     | 614,000                                                 | .97                   | .94              | 99.7      |
| By sedimentation and filtration through sand, . . .                                                                    | 13 A              | .19                                                    | 2.0                     | 160,000                                                 | .95                   | .91              | 99.6      |
| By chemical precipitation and filtration through sand,                                                                 | 19                | .17                                                    | 2.0                     | 200,000                                                 | .97                   | .95              | 99.9      |
| By straining through coke and filtration through sand,                                                                 | 14 A              | .19                                                    | 2.0                     | 320,000                                                 | .96                   | .94              | 99.8      |
| By rapid filtering through gravel, aided by a current of air (Filter No. 51) and filtration through sand or coke.      | 53                | .19                                                    | 2.0                     | 681,000                                                 | .93                   | .91              | 72.3      |
|                                                                                                                        | 55                | .40                                                    | 2.4                     | 667,000                                                 | .91                   | .88              | 68.5      |
|                                                                                                                        | 57                | coke.                                                  | -                       | 704,000                                                 | .92                   | .90              | 77.9      |
| By rapid filtration through coke, aided by current of air (Filter No. 52) and filtration through sand or coke.         | 54                | .19                                                    | 2.0                     | 668,000                                                 | .95                   | .93              | 68.5      |
|                                                                                                                        | 56                | .40                                                    | 2.4                     | 695,000                                                 | .93                   | .91              | -         |
|                                                                                                                        | 58                | coke.                                                  | -                       | 702,000                                                 | .94                   | .93              | 74.8      |

### COMPARISON OF RESULTING LIQUIDS.

Comparing the resulting liquids after the treatment of sewage by these various methods of removing sludge, it is noticeable that the organic matter in the liquids after rapid filtration combined with aëration is of a different character from the organic matter in the sewage resulting from the other sludge-removing processes. That is to say, even when the organic matter, as shown by the albuminoid ammonia, is present in quantities as great as in the other partially purified sewages, it has passed through such chemical and biological changes that it develops offensive odors very slowly on standing.

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### THE DISPOSAL OF WASTE LIQUORS FROM INDUSTRIAL WORKS.

Investigations upon the disposal of waste liquors from the processes of paper making, wool scouring and tanning have been begun.

#### *Paper Making.*

All rags are cleaned before being made into paper by being boiled in a solution of caustic soda, caustic lime, or a mixture of soda ash and lime, to free them from grease, dirt and coloring matters. The resulting liquor is very highly polluted with organic matter and when discharged into a small body of water may create a nuisance. On September 8, a filter was started to see if this waste liquor could be purified by filtration through sand. The liquor applied to the filter is very alkaline, and the results obtained indicate that while a considerable purification may be obtained by filtration through sand, yet the organic matter present is of a nature not easily attacked by the bacteria in the filter and the degree of alkalinity obtained is unfavorable for the growth of the nitrifying bacillus. (For results obtained see page 501.) When, however, this liquor is diluted by the large volume of wash water used in paper making, the resulting dirty water or sewage can in most cases probably be easily purified by filtration. The volume of wash water is very large.

#### *Wool Scouring.*

The condition of wool when first obtained from the sheep's back is such that mordanting and dyeing without removal of the grease, dirt, etc., would be impossible. Besides the mechanically held dirt

the impurities are of a two-fold character, the "wool fat," soluble in ether, and the "wool perspiration," soluble in water. The two are frequently included under the name of the "yolk" or "suint" of the wool.

Wool fat is not a fat as commonly understood, that is, it is not a glycerate. By treating it with boiling alcohol it may be separated into two portions, one soluble and the other insoluble in this liquid. The soluble portion consists mainly of cholesterine and isocholesterine, together with compounds of these bodies with organic acids. The insoluble portion consists mainly of cholesterine and isocholesterine with oleic and fatty acids. Grease and dirt are present on the wool to such an extent that different wools lose from 15 to 75 per cent. by weight in passing through the washing, scouring and rinsing processes. It is the common method to remove these impurities by solutions of alkaline carbonates and soaps. In the centres of the French and Belgian woollen industries the wool is first washed with water, the solution evaporated, and potassium carbonate recovered. This potassium carbonate may be present to the amount of 4 per cent. of the weight of the raw wool. In this country little if anything is done towards recovering the potash salts, the preliminary treatment with water being generally dispensed with. In many places abroad the waste scouring liquors are collected in stone-lined pits and neutralized or acidified by sulphuric acid, and the fatty matters, which rise to the surface, are collected in filter bags and sold. This of course causes a partial purification of the liquor, but all the dirt and a considerable portion of the fatty matter still remain in it. There are very few places in this country, however, where even this partial purification is undertaken, the waste liquor in its entirety being allowed to run into and pollute the neighboring stream. A process of wool cleansing, growing in favor, is one by which the fatty matters are first removed by naphthalene or gasoline and the remaining dirt subsequently removed by the usual scouring process, the fat removed by the first process being a valuable by-product.

Careful calculations have shown that the volume of water used in a wool-scouring plant is about 100 gallons per pound of wool scoured; a small and varying proportion of this volume being directly used in the scouring bowls and the remainder being used for rinsing the wool after scouring.

Beginning September 8, the strong waste liquor from the scouring process has been applied to a filter containing 5 feet in depth of sand

of an effective size of 0.25 millimeter. The rate of application has been equal to about 17,000 gallons per acre daily, and the results so far obtained have made clear that while this liquor can be filtered through sand and a considerable portion of the organic matters removed, yet it is with such difficulty and at such low rates in gallons per acre daily that a preliminary treatment, to remove a large part of the dirt and fatty matters before filtration, is essential. Subsequent filtration of the effluent of this filter improves it little if any, the character of the organic matter and the degree of alkalinity of the original liquor and the effluent being such that the bacteria attack it very feebly. The numbers of bacteria in the liquor and in the effluent are enormous, but the nitrifying bacillus does not seem to develop and the organic impurities are apparently of such a stable character that decomposition and putrefaction take place very slowly.

#### *Removal of Fats and Dirt before Filtration.*

As already mentioned, a certain portion of the fats present in the wool liquor can be collected by the addition of sulphuric acid to the liquor, but a more complete removal of the fats and dirt can be effected by the addition of calcium chloride. This precipitates the fat as a lime soap and the precipitate carries down with it all the dirt in suspension in the liquid, leaving a clear but highly colored solution. It seems probable, and experiments are now under way to test the fact, that, by hot pressing this precipitate, enough fat may be obtained to make the process pay for itself. The clarified liquor is rich in organic matters in solution but they are of the same stable character as before mentioned and pass through 5 feet of sand with very little change.

#### *Tannery Sewage.*

In connection with the investigations in regard to the condition of the Neponset River two experimental filters have been operated at Norwood, Mass., to determine the feasibility of purifying, by filtration through sand, the waste liquors from preparing and tanning hides.

A filter was constructed containing 2 feet in depth of sand, of an effective size of 0.14 millimeter, over gravel under-drains. It was not feasible to have at the place desired a filter with a greater depth of sand, owing to the slope of the land and the necessity of having the sewage run on to the filter by gravity and away from the under-drains in the sewer which carries the tannery sewage to the river.



Sewage was first applied to this filter September 27. The sewage is a mixture of the waste liquors from all the processes carried on in the tannery, and it has been applied to this shallow filter at an average rate of 55,000 gallons per acre daily, and with the results given below.

*Table showing Average Analyses of Sewage applied to and Effluent from the Filter.*

[Parts per 100,000.]

|                     | Free<br>Ammonia. | Albuminoid<br>Ammonia. | Chlorine. | NITROGEN AS |           | Oxygen<br>Consumed. |
|---------------------|------------------|------------------------|-----------|-------------|-----------|---------------------|
|                     |                  |                        |           | Nitrates.   | Nitrites. |                     |
| Sewage, . . . . .   | 3.1000           | 3.1600                 | 312       | .1600       | .0015     | 55.00               |
| Effluent, . . . . . | 2.3400           | .6000                  | 290       | 1.0500      | .0100     | 7.50                |

The sewage is very strong and offensive, being highly charged with decaying animal tissues and the bran added to cause fermentation to take place. It is also highly colored by the different aniline dyes used in coloring the hides, and these coloring matters, after the first few weeks of operation of the filter, failed to be completely removed. The sewage applied to the filter has been almost entirely that resulting from the preparation of the hides, the spent tan liquor forming but a very small proportion of the waste liquors flowing from the tannery. It need hardly be said that tannic acid if applied in any quantity would be very prejudicial to decomposition and nitrification in the filter.

#### *Precipitation with Lime.*

In one of the processes at the tannery a large amount of lime is used, and in consequence of this, there is an almost continuous stream of lime water flowing into and mixing with the remainder of the sewage; and it is evident that, if settling tanks were properly arranged, and the flow of lime water regulated, a large percentage of the sludge could be precipitated out. Preliminary experiments have shown that probably 60 per cent. of the organic matter can be removed in this way, but the resulting supernatant sewage is very rich in organic matter in solution.

A small filter, to which this supernatant sewage is applied at an average rate of 120,000 gallons per acre daily, was started toward the end of the year, and is at the present time, July, 1896, in a

state of active nitrification and giving a clear almost odorless effluent. These experiments have demonstrated that this sewage can be purified by filtration.

#### WORK OF THE FILTERS FOR 1895.

The experimental filters in operation during 1895 have included all in operation at the end of 1894, together with the addition of filters Nos. 51, 52, 53, 54, 55, 56, 57, 58, 59, 60 and 61. Filters 1 to 10 inclusive are out of doors, and are each one two-hundredth of an acre in area; filters 12 to 61 inclusive are within the buildings and are one twenty-thousandth of an acre in area, with the exception of Filter No. 59, which is one ten-thousandth of an acre in area, and filters Nos. 51 and 52, which are one three-thousandth of an acre in area.

##### *Filter No. 1.*

This filter, containing 60 inches in depth of coarse sand of an effective size of 0.48 millimeter, was purifying sewage very poorly at the beginning of the year, owing to the destruction of nitrification by too long continued resting during the cold weather of October and November, 1894. This poor purification continued throughout January and February, and not until the middle of March did the effluent begin to show good oxidation and nitrification in the filter. Observations were made daily during this period of the presence of frost, and efforts made to re-establish nitrification by picking holes in the surface of the filter, to allow the sewage to pass more rapidly below the surface, and by seeking to remove frost by the application of large doses of sewage.

On January 25 the filter was covered with two thicknesses of canvas stretched over a frame, as in previous years, and this cover was removed March 13. On March 23 the surface was spaded over (corresponding to ploughing) to a depth of 4 inches. Good results were obtained from the first of April throughout the remainder of the year. August 20 the surface was raked (corresponding to harrowing) to a depth of 3 inches and on October 22 and November 9 it was spaded over to a depth of 6 inches. On November 15 it was covered for the winter with canvas stretched over a frame. The quantity of sewage applied to the filter was at the rate of 80,000 gallons per acre daily during the first half of the year and 60,000 gallons per acre daily during the last half of the year.

The monthly averages of the weekly analyses of the effluent of this filter are presented in the next table.

*Monthly Averages of Analyses of Effluent of Filter No. 1.*

[Parts per 100,000.]

| 1895.        | Quantity Applied.<br>Gallons per Acre<br>Daily for Six<br>Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time<br>Sewage<br>Remained<br>on<br>Surface.<br>Hours and<br>Minutes. | APPEARANCE. |        | AMMONIA. |             |           | NITROGEN<br>AS |           | Oxygen Consumed. | Bacteria per<br>Cubic<br>Centimeter. |
|--------------|---------------------------------------------------------------------------|-------------------------|-----------|---------------------------------------------------------------------------------|-------------|--------|----------|-------------|-----------|----------------|-----------|------------------|--------------------------------------|
|              |                                                                           | Sewage.                 | Effluent. |                                                                                 | Turbidity.  | Color. | Free.    | Albuminoid. | Chlorine. | Nitrates.      | Nitrites. |                  |                                      |
| January, .   | 84,400                                                                    | 47                      | 37        | 4h. 19m.                                                                        | Decided.    | .77    | 3.7000   | .2660       | 9.49      | 0.26           | .0960     | 1.79             | 211,000                              |
| February, .  | 80,000                                                                    | 49                      | 38        | 1h. 52m.                                                                        | Decided.    | .54    | 2.4875   | .1675       | 8.90      | 1.09           | .3500     | 1.17             | 88,200                               |
| March, .     | 76,900                                                                    | 44                      | 40        | 1h. -                                                                           | Decided.    | .83    | 2.1375   | .2350       | 10.39     | 1.25           | .2905     | 1.96             | 177,000                              |
| April, .     | 55,400                                                                    | 47                      | 43        | 8m.                                                                             | Decided.    | .33    | .4600    | .0867       | 10.84     | 2.64           | .2833     | 0.97             | 85,000                               |
| May, .       | 80,000                                                                    | 59                      | 57        | 4m.                                                                             | Slight.     | .19    | .0222    | .0261       | 12.86     | 3.28           | .0053     | 0.28             | 23,000                               |
| June, .      | 83,200                                                                    | 69                      | 66        | 2m.                                                                             | Slight.     | .17    | .0830    | .0350       | 15.59     | 4.88           | .0100     | 0.31             | 22,000                               |
| July, .      | 77,000                                                                    | 69                      | 71        | 3m.                                                                             | V. slight.  | .14    | .0755    | .0240       | 14.63     | 4.10           | .0026     | 0.23             | 27,800                               |
| August, .    | 56,600                                                                    | 70                      | 74        | 3m.                                                                             | Slight.     | .13    | .0337    | .0236       | 14.06     | 3.70           | .0018     | 0.25             | 33,000                               |
| September, . | 60,000                                                                    | 67                      | 72        | 2m.                                                                             | None.       | .11    | .0564    | .0211       | 15.61     | 4.25           | .0025     | 0.19             | 3,700                                |
| October, .   | 45,500                                                                    | 56                      | 59        | 5m.                                                                             | None.       | .13    | .1148    | .0248       | 12.24     | 2.92           | .0014     | 0.25             | 15,540                               |
| November, .  | 49,600                                                                    | 62                      | 52        | 19m.                                                                            | V. slight.  | .16    | .4510    | .0380       | 7.91      | 1.86           | .0467     | 0.44             | 41,500                               |
| December, .  | 60,000                                                                    | 53                      | 47        | 49m.                                                                            | Decided.    | .30    | 1.0250   | .0680       | 8.25      | 1.92           | .1100     | 0.47             | 63,000                               |

Sewage applied, 400 gallons six times a week, January 1 to March 31; 200 gallons twelve times a week, April 1 to July 31; 300 gallons six times a week, August 1 to 18; 150 gallons twelve times a week, August 19 to October 21; 150 gallons three times a week, October 22 to 31; 150 gallons twelve times a week, November 1 to December 31. Tank covered with canvas January 25 to March 13, and November 15 to December 31. April 11 to 20, experiment interrupted by freshet. Trap attached to outlet June 19 to July 3, and a trap 18 inches high August 31 to September 27. September 9, trap turned down and effluent pipe flushed out. August 31, white worms found in under-drains, and under-drains flushed out. Surface raked about 1 inch deep each week except twice in February and once in April. Surface dug over 4 inches deep March 23; 3 inches deep August 20 and December 27; 6 inches deep October 22 and November 8. During January, 8½ inches of snow and 3½ inches of ice removed from surface; during March, 2½ inches of snow and ½ inch of ice removed.

*Filter No. 2.*

This filter, containing 60 inches in depth of fine sand of an effective size of 0.08 millimeter, trenched with medium fine sand of an effective size of 0.19 millimeter, had, at the beginning of the year, begun to feel the effects of the prolonged resting during the cold weather of October and November, 1894. The effluent of the filter continued to be of a poor quality during January, February and March, but during April the nitrates were much higher, although the free ammonia was still high. From the beginning of May throughout the remainder of the year the filter was in good condition and the effluent of a satisfactory quality. During the first two months of the year the sewage applied to the filter disappeared

below the surface very slowly, and from February 8 to 18 the trenches remained partially covered with sewage and none was applied. The average rate of application of sewage during these two months was 18,000 gallons per acre daily. During the remainder of the year the approximate rate of application was 38,000 gallons per acre daily. On March 25 the sand of the trenches was removed, the sides of the trenches raked, the fine sand at the bottom of the trenches spaded over 3 inches deep and the sand of the trenches replaced. On September 9 this operation was repeated. The results for the year are shown by the monthly averages of the weekly analyses.

*Monthly Averages of Analyses of Effluent of Filter No. 2.*

[Parts per 100,000.]

| 1895.        | Quantity<br>Applied.<br><br>Gallons<br>per Acre<br>Daily<br>for Six<br>Days in a<br>Week. | TEMPERA-<br>TURE.<br>DEG F. |           | Length of<br>Time<br>Sewage<br>Remained<br>on<br>Surface.<br><br>Hours and<br>Minutes. | APPEARANCE. |        | AMMONIA. |             | NITROGEN<br>AS |            | Oxygen Consumed. | Bacteria per Cubic<br>Centimeter. |           |
|--------------|-------------------------------------------------------------------------------------------|-----------------------------|-----------|----------------------------------------------------------------------------------------|-------------|--------|----------|-------------|----------------|------------|------------------|-----------------------------------|-----------|
|              |                                                                                           | Sewage.                     | Effluent. |                                                                                        | Turbidity.  | Color. | Free.    | Albuminoid. | Chlorine.      | Nitrates.  |                  |                                   | Nitrites. |
|              |                                                                                           |                             |           |                                                                                        |             |        |          |             |                |            |                  |                                   |           |
| January, .   | 22,500                                                                                    | 48                          | 38        | 12h. -                                                                                 | None.       | .08    | 1.2440   | .0288       | 7.59           | 1.40 .0354 | .30              | 1,540                             |           |
| February, .  | 13,400                                                                                    | 46                          | 36        | 12h. -                                                                                 | None.       | .10    | 0.9867   | .0380       | 7.88           | 0.70 .0039 | .37              | 1,940                             |           |
| March, .     | 34,100                                                                                    | 46                          | 37        | 2h. 3m.                                                                                | None.       | .17    | 2.2350   | .0675       | 8.19           | 0.36 .0213 | .67              | 2,765                             |           |
| April, .     | 27,700                                                                                    | 48                          | 42        | 28m.                                                                                   | None.       | .15    | 1.9000   | .0507       | 7.22           | 2.10 .0350 | .37              | 89                                |           |
| May, .       | 40,000                                                                                    | 57                          | 54        | 25m.                                                                                   | None.       | .08    | 0.4450   | .0250       | 8.53           | 3.24 .0009 | .20              | 38                                |           |
| June, .      | 41,600                                                                                    | 68                          | 61        | 7m.                                                                                    | None.       | .09    | 0.0121   | .0179       | 11.17          | 4.09 .0001 | .17              | 38                                |           |
| July, .      | 38,500                                                                                    | 69                          | 68        | 7m.                                                                                    | None.       | .08    | 0.0009   | .0154       | 14.86          | 3.60 .0001 | .12              | 7                                 |           |
| August, .    | 38,500                                                                                    | 69                          | 70        | 9m.                                                                                    | None.       | .06    | 0.0009   | .0134       | 13.95          | 3.74 .0001 | .09              | 39                                |           |
| September, . | 40,000                                                                                    | 66                          | 70        | 14m.                                                                                   | None.       | .05    | 0.0008   | .0156       | 13.98          | 3.84 .0003 | .10              | 60                                |           |
| October, .   | 31,100                                                                                    | 55                          | 58        | 55m.                                                                                   | None.       | .06    | 0.0019   | .0120       | 14.68          | 4.21 .0002 | .30              | 14                                |           |
| November, .  | 35,400                                                                                    | 63                          | 53        | 1h 55m.                                                                                | None.       | .07    | 0.0130   | .0143       | 8.36           | 3.10 .0002 | .10              | 5                                 |           |
| December, .  | 41,000                                                                                    | 54                          | 42        | 8h. 31m.                                                                               | None.       | .09    | 0.0628   | .0166       | 7.85           | 1.94 .0009 | .15              | 11                                |           |

Sewage applied, trenches were filled six times a week January 1 to March 26, except three days in January and eleven days in February. Amount of applied sewage varied from 40 to 190 gallons; 200 gallons six times each week, March 26 to October 22; 100 gallons three times a week, October 23 to 31; 200 gallons six times a week, November 1 to December 31. April 11 to 20, experiment interrupted by frost. March 25, sand removed from trenches; sides of trenches raked; bottoms of trenches dug over 3 inches deep; sand thoroughly mixed and replaced in trenches. August 31 to September 6, a trap 18 inches high attached to outlet. September 9, grass and weeds removed from surface of tank; sand removed from trenches; bottoms and sides of trenches scraped and dirty sand piled on middle of tank; sides of trenches raked, and bottoms of trenches dug over 4 inches deep; sand thoroughly mixed and replaced in trenches. Surface of trenches raked 1 inch deep each week, except two omissions in February and one in April. October 22, surface of trenches dug over 3 inches deep. During January, 12½ inches of snow removed from entire surface, 9½ inches of ice from outer trench, and 5½ inches from inner; during February, ½ inch of snow removed from surface, 4½ inches of ice from outer trench and 8 inches from inner; during March, 5 inches of snow removed from surface; during December, 8 inches of snow removed from surface, 1½ inches of ice from each trench.

*Filter No. 4.*

This filter, of fine river silt of an effective size of 0.04 millimeter and containing two trenches of coarse sand of an effective size of 0.48 millimeter, was giving an effluent of a good quality at the beginning of the year, but its surface was in poor condition and disposed of the applications of sewage with difficulty, the average

rate of filtration being only 7,000 gallons per acre daily for the first three months of the year, and from February 6 to 18 inclusive no sewage was applied to the filter. For the remainder of the year the average rate of filtration was 18,300 gallons per acre daily. The nitrates in the effluent were the lowest during March and April, but the ammonias were also low. On March 27 the sand of the trenches was removed, the sides of the trenches raked, the fine sand at the bottom of the trenches dug over to the depth of 3 inches and the coarse sand replaced. This treatment was repeated September 7, at which date a small amount of the dirty sand at the bottom of the trenches was removed and placed upon the surface of the filter. The quality of the effluent was quite satisfactory throughout the year, as shown by the following table, giving the monthly averages of the weekly analyses:—

*Monthly Averages of Analyses of Effluent of Filter No. 4.*

[Parts per 100,000.]

| 1895.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage Remained on Surface.<br>Hours and Minutes. | APPEARANCE. |        | AMMONIA. |             | NITROGEN AS |           |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|------------------------------------------------------------------|-------------|--------|----------|-------------|-------------|-----------|-----------|------------------|--------------------------------|
|              |                                                                     | Sewage.                 | Effluent. |                                                                  | Turbidity.  | Color. | Free.    | Albuminoid. | Chlorine.   | Nitrates. | Nitrites. |                  |                                |
| January, .   | 7,500                                                               | 47                      | 43        | 15h. -                                                           | None.       | .09    | .0006    | .0086       | 7.33        | 1.71      | .0000     | .14              | 8                              |
| February, .  | 4,600                                                               | 48                      | 43        | 14h. -                                                           | None.       | .11    | .0010    | .0090       | 7.40        | 1.47      | .0000     | .17              | 90                             |
| March, .     | 9,000                                                               | 45                      | 42        | 12h. 38m.                                                        | V. slight.  | .12    | .0008    | .0278       | 7.93        | 0.71      | .0001     | .23              | 2,590                          |
| April, .     | 18,000                                                              | 47                      | 41        | 17m.                                                             | V. slight.  | .18    | .0252    | .0595       | 7.44        | 0.76      | .0061     | .34              | 597                            |
| May, .       | 19,800                                                              | 59                      | 55        | 5m.                                                              | None.       | .20    | .1034    | .0310       | 5.96        | 1.73      | .0025     | .29              | 84                             |
| June, .      | 20,800                                                              | 68                      | 61        | 2m.                                                              | None.       | .14    | .1412    | .0162       | 9.10        | 3.05      | .0085     | .19              | 20                             |
| July, .      | 19,300                                                              | 69                      | 69        | 3m.                                                              | None.       | .12    | .1380    | .0189       | 11.62       | 2.39      | .0049     | .19              | 39                             |
| August, .    | 20,700                                                              | 69                      | 71        | 8m.                                                              | None.       | .11    | .0039    | .0145       | 12.93       | 2.43      | .0005     | .18              | 61                             |
| September, . | 17,600                                                              | 66                      | 71        | 5m.                                                              | V. slight.  | .10    | .0063    | .0137       | 13.86       | 2.54      | .0012     | .18              | 44                             |
| October, .   | 16,300                                                              | 56                      | 61        | 50m.                                                             | None.       | .08    | .0011    | .0091       | 13.32       | 3.47      | .0001     | .12              | 272                            |
| November, .  | 16,900                                                              | 62                      | 54        | 1h. 46m.                                                         | None.       | .08    | .0009    | .0094       | 9.44        | 2.57      | .0000     | .10              | 31                             |
| December, .  | 20,000                                                              | 53                      | 48        | 33m.                                                             | None.       | .09    | .0009    | .0092       | 6.60        | 1.84      | .0000     | .12              | 23                             |

Sewage applied, trenches filled three times a week, January 1 to March 29, except two days in January, six days in February, and three days in March. Quantity of applied sewage varied from 40 to 190 gallons; 200 gallons three times a week, March 30 to October 21; 100 gallons three times a week, October 22 to November 1; 200 gallons three times a week, November 2 to December 31. April 11 to 20, experiment interrupted by freshet. August 31 to September 6, a trap 18 inches high attached to outlet. March 27, sand removed from trenches; sides of trenches raked and bottoms of trenches dug over to a depth of 3 inches; sand thoroughly mixed and replaced in trenches. September 7, grass and weeds removed from surface of tank; sand removed from trenches; bottoms and sides of trenches scraped and dirty sand piled on middle of tank; sides of trenches raked and bottoms dug over 4 inches deep; sand thoroughly mixed and replaced in trenches. Surface of trenches raked 1 inch deep once in January, not at all in February, three times in March, and once each week during the remainder of the year. October 22 and December 27, surface of trenches dug over 3 inches deep. During January, 12½ inches of snow removed from entire surface, 12½ inches of ice from outer trench, and 7½ inches of ice from inner; during February, 2 inches of snow removed from surface, 10 inches of ice from outer trench and 5 inches from inner; during March, 4 inches of snow removed from surface, 1 inch of ice from outer trench and ½ inch from inner; during December, 8 inches of snow removed from entire surface.

*Filter No. 5.*

This filter, of fine gravel stones of an effective size of 1.40 millimeters, took the applied sewage without difficulty at an average rate of 76,000 gallons per acre daily during the first three months of the year, but the effluent was, until the middle of March, of a very poor quality, owing largely to the destruction of nitrification toward the end of 1894. From the middle of March until the end of the year the effluent was of as good a quality as could be expected from a filter of this coarse material entirely under-drained and only 5 feet in depth. The free ammonia of the effluent was high throughout the year, a natural result of the quick passage through the filter of sewage very high in free ammonia. The filter was spaded over to the depth of 4 inches March 4, raked 3 inches deep August 21, and spaded to a depth of 6 inches October 22. The results of the monthly averages of the weekly analyses are given in the following table:—

*Monthly Averages of Analyses of Effluent of Filter No. 5.*

[Parts per 100,000.]

| 1895.        | Quantity<br>Applied.<br><br>Gallons<br>per Acre<br>Daily for Six<br>Days in a<br>Week. | TEMPERA-<br>TURE.<br>DEG. F. |          | Length of<br>Time<br>Sewage<br>Remained<br>on<br>Surface.<br><br>Hours and<br>Minutes. | APPEARANCE. |        | AMMONIA. |             | NITROGEN<br>AS |           | Oxygen Consumed. | Bacteria per<br>Cubic<br>Centimeter. |           |
|--------------|----------------------------------------------------------------------------------------|------------------------------|----------|----------------------------------------------------------------------------------------|-------------|--------|----------|-------------|----------------|-----------|------------------|--------------------------------------|-----------|
|              |                                                                                        | Sewage.                      | Effluent |                                                                                        | Turbidity.  | Color. | Free.    | Albuminoid. | Chlorine.      | Nitrates. |                  |                                      | Nitrites. |
| January, .   | 74,000                                                                                 | 41                           | 40       | 8h. 13m.                                                                               | Decided.    | .71    | 3.5700   | .2380       | 9.01           | 0.63      | .0133            | 1.32                                 | 339,000   |
| February, .  | 73,300                                                                                 | 41                           | 35       | 7h. -                                                                                  | Decided.    | .80    | 2.7250   | .2250       | 9.28           | 0.93      | .0185            | 1.42                                 | 137,000   |
| March, .     | 80,000                                                                                 | 40                           | 39       | 19m.                                                                                   | Great.      | .60    | 1.2000   | .2100       | 7.04           | 2.19      | .0312            | 1.38                                 | 163,000   |
| April, .     | 80,000                                                                                 | 47                           | 43       | 2m.                                                                                    | Decided.    | .35    | 0.4167   | .1200       | 9.76           | 2.71      | .0090            | 0.79                                 | 88,000    |
| May, .       | 80,000                                                                                 | 58                           | 59       | 4m.                                                                                    | Decided.    | .35    | 0.3050   | .0740       | 13.96          | 2.87      | .0033            | 0.60                                 | 215,000   |
| June, .      | 83,200                                                                                 | 69                           | 70       | 2m                                                                                     | Decided.    | .33    | 0.6350   | .0860       | 14.78          | 3.76      | .0260            | 0.60                                 | 145,000   |
| July, .      | 77,000                                                                                 | 69                           | 71       | 3m.                                                                                    | Decided.    | .30    | 0.4600   | .0640       | 15.39          | 3.97      | .0065            | 0.40                                 | 147,000   |
| August, .    | 55,500                                                                                 | 71                           | 75       | 3m.                                                                                    | Decided.    | .30    | 0.5687   | .0927       | 14.08          | 2.90      | .0110            | 0.58                                 | 186,000   |
| September, . | 60,000                                                                                 | 67                           | 71       | 2m.                                                                                    | Slight.     | .14    | 0.1550   | .0260       | 15.62          | 3.55      | .0086            | 0.26                                 | 28,000    |
| October, .   | 44,400                                                                                 | 55                           | 58       | 14m.                                                                                   | Slight.     | .18    | 0.4884   | .0502       | 10.72          | 3.06      | .0118            | 0.39                                 | 47,000    |
| November, .  | 53,100                                                                                 | 53                           | 51       | 7m.                                                                                    | Decided.    | .20    | 0.6700   | .0687       | 8.97           | 1.18      | .0517            | 0.51                                 | 256,000   |
| December, .  | 58,800                                                                                 | 49                           | 43       | 10m.                                                                                   | Decided.    | .18    | 0.7400   | .1210       | 7.93           | 1.93      | .0660            | 0.79                                 | 79,500    |

Sewage applied, 400 gallons six times a week, January 1 to March 31; 200 gallons twelve times a week, April 1 to July 31; 300 gallons six times a week, August 1 to 21; 150 gallons twelve times a week, August 22 to October 21; 150 gallons three times a week, October 22 to 31; 150 gallons twelve times a week, November 1 to December 11; 300 gallons six times a week, December 12 to 18; 150 gallons twelve times a week, December 19 to 31. April 11 to 20, experiment interrupted by freshet. August 30 and 30, white worms found in under-drains, and under-drains flushed out. August 31 to December 17, a trap 18 inches high was attached to outlet. September 9, trap turned down and pipe flushed out. Surface raked 1 inch deep each week, except two omissions each in January and February. March 23, surface spaded 4 inches deep; October 22, 6 inches deep. During January, 14½ inches of snow and 8½ inches of ice removed from surface; during February, 8½ inches of snow and 8½ inches of ice removed; during March, 5½ inches of snow removed; during December, 9½ inches of snow and ½ inch of ice removed.

*Filter No. 6.*

This filter contains 44 inches in depth of mixed coarse and fine sand of an effective size of 0.35 millimeter. In common with some of the other outdoor filters it was giving an effluent of a very poor quality at the beginning of the year, owing to the destruction of nitrification during the cold weather of October and November, 1894. Efforts were made to re-establish nitrification in the filter by keeping its surface in such a condition that it would dispose of the applied sewage freely, but nitrification did not become active until the warmer weather of March came to its aid. From the first part of April throughout the remainder of the year the nitrates of the effluent were very high and the quality of the effluent exceedingly satisfactory, especially considering the strength of the applied sewage and the shallowness of the filter. Sewage was applied to the filter at an average rate of 59,800 gallons per acre daily for the first three months of the year and the average rate of application from April 1 until the end of the year was 58,500 gallons per acre daily. The surface of the filter was spaded over 4 inches deep on March 23, raked to a depth of 3 inches August 20 and spaded over to a depth of 6 inches October 22. The following table shows the work of the filter for the year:—

*Monthly Averages of Analyses of Effluent of Filter No. 6.*

[Parts per 100,000.]

| 1895.        | Quantity<br>Applied.<br><br>Gallons<br>per Acre<br>Daily<br>for Six<br>Days in a<br>Week. | TEMPERA-<br>TURE.<br>DEG. F. |           | Length of<br>Time<br>Sewage<br>Remained<br>on<br>Surface.<br><br>Hours and<br>Minutes. | APPEARANCE. |        | AMMONIA. |             | NITROGEN<br>AS |           | Oxygen Consumed. | Bacteria per Cubic<br>Centimeter. |          |
|--------------|-------------------------------------------------------------------------------------------|------------------------------|-----------|----------------------------------------------------------------------------------------|-------------|--------|----------|-------------|----------------|-----------|------------------|-----------------------------------|----------|
|              |                                                                                           | Sewage.                      | Effluent. |                                                                                        | Turbidity.  | Color. | Free.    | Albuminoid. | Chlorine.      | Nitrates. |                  |                                   | Nitrites |
| January, .   | 57,800                                                                                    | 47                           | 37        | 10h. 35m.                                                                              | Decided.    | .58    | 2.3020   | .1500       | 9.54           | 0.45      | .1370            | 1.15                              | 49,400   |
| February, .  | 61,700                                                                                    | 50                           | 35        | 9h.                                                                                    | Decided.    | .68    | 3.0825   | .1850       | 9.49           | 0.12      | .0270            | 1.20                              | 30,700   |
| March, .     | 60,000                                                                                    | 47                           | 38        | 41m.                                                                                   | Decided.    | .51    | 1.7750   | .1425       | 7.08           | 1.37      | .2438            | 1.09                              | 45,500   |
| April, .     | 60,000                                                                                    | 48                           | 43        | 17m.                                                                                   | Decided.    | .30    | 0.7327   | .0829       | 8.86           | 2.16      | .2333            | 0.88                              | 69,000   |
| May, .       | 60,000                                                                                    | 57                           | 56        | 5m.                                                                                    | Slight.     | .19    | 0.0094   | .0386       | 11.32          | 3.13      | .0031            | 0.32                              | 17,220   |
| June, .      | 62,400                                                                                    | 68                           | 68        | 12m.                                                                                   | V. slight.  | .18    | 0.0051   | .0461       | 12.73          | 4.89      | .0003            | 0.29                              | 12,192   |
| July, .      | 58,100                                                                                    | 68                           | 70        | 3m.                                                                                    | None.       | .12    | 0.0014   | .0255       | 14.32          | 4.43      | .0002            | 0.17                              | 4,928    |
| August, .    | 55,500                                                                                    | 69                           | 74        | 3m.                                                                                    | None.       | .11    | 0.0026   | .0311       | 15.33          | 3.65      | .0007            | 0.21                              | 6,167    |
| September, . | 60,000                                                                                    | 66                           | 71        | 6m.                                                                                    | None.       | .11    | 0.0327   | .0340       | 14.00          | 3.77      | .0053            | 0.21                              | 3,638    |
| October, .   | 44,400                                                                                    | 55                           | 56        | 1h. 28m.                                                                               | None.       | .09    | 0.0373   | .0230       | 11.64          | 2.32      | .0290            | 0.19                              | 2,248    |
| November, .  | 53,000                                                                                    | 55                           | 51        | 1h. 43m.                                                                               | V. slight.  | .12    | 0.2040   | .0289       | 8.64           | 2.44      | .0790            | 0.34                              | 5,120    |
| December, .  | 57,700                                                                                    | 49                           | 42        | 10m.                                                                                   | V. slight.  | .19    | 0.5600   | .0500       | 8.58           | 1.70      | .1975            | 0.41                              | 4,491    |

Sewage applied, 300 gallons six times a week, January 1 to October 22; 150 gallons three times a week, October 23 to 31; 300 gallons 6 times a week, November 1 to December 31. April 11 to 20, experiment interrupted by frost. August 31 to September 11, a trap 18 inches high was attached to outlet pipe. September 9, trap turned down and pipe flushed out. Surface raked 1 inch deep each week, except two omissions in January and two in February. March 23, surface spaded over 4 inches deep; August 20, 3 inches deep; October 22, 6 inches deep. During January, 11½ inches of snow and 8½ inches of ice removed from surface; during February, 17 inches of snow and 8½ inches of ice removed; during March, 8 inches of snow removed; during December, 8 inches of snow and ½ inch of ice removed.

*Filter No. 9 A.*

This filter contains 5 feet in depth of sand of an effective size of 0.17 millimeter. At the beginning of the year nitrification had almost ceased in the filter, owing to the prolonged resting during the latter part of 1894. The surface of the filter was in fairly good condition and the applied sewage passed below the surface as readily as is usual in cold winter weather. On February 1 the filter was covered with canvas stretched over a frame, but nitrification did not become re-established until warmer weather began in March. Throughout the remainder of the year the filter was in good condition, nitrification was active and the effluent of a satisfactory quality. As the cold weather of fall and early winter began, the process of nitrification became somewhat less active and the ammonias of the effluent greater, but the physical condition of the filter was excellent and it was taking the applied sewage readily. The character of the effluent tends to show that a filter of this depth, entirely under-drained and containing sand of this grade, cannot, with the quantities of sewage applied, cause an entire transformation of such large quantities of nitrogen as are now present in the sewage, in the form of free ammonia and organic nitrogen, into nitrogen in the form of nitrates, except during those periods of warm weather when nitrification is most active. The filter was spaded over 4 inches deep March 23, raked to a depth of 3 inches August 20, and spaded over to a depth of 6 inches September 7 and November 8. The following table shows the monthly averages of the weekly analyses : —



*Monthly Averages of Analyses of Effluent of Filter No. 9 A.*

[Parts per 100,000.]

| 1895.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage Remained on Surface.<br>—<br>Hours and Minutes. | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|-----------------------------------------------------------------------|-------------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|              |                                                                     | Sewage.                 | Effluent. |                                                                       | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |
| January, .   | 80,000                                                              | 50                      | 36        | 7h. 50m.                                                              | Decided.    | .62    | 3.8700   | .1960       | 8.41      | 0.29        | .0276     | 1.37             | 145,000                        |
| February, .  | 73,300                                                              | 46                      | 35        | 12h. 40m.                                                             | Decided.    | .59    | 3.7125   | .1700       | 8.93      | 0.19        | .0217     | 1.14             | 107,100                        |
| March, .     | 80,000                                                              | 44                      | 38        | 1h. 20m.                                                              | Decided.    | .52    | 2.0500   | .1725       | 7.96      | 1.03        | .0575     | 0.99             | 76,400                         |
| April, .     | 53,300                                                              | 46                      | 44        | 1h. 22m.                                                              | Slight.     | .25    | 0.7808   | .0871       | 8.41      | 2.40        | .1500     | 0.63             | 29,000                         |
| May, .       | 80,000                                                              | 58                      | 58        | 57m.                                                                  | None.       | .14    | 0.0068   | .0255       | 10.10     | 3.08        | .0001     | 0.22             | 1,237                          |
| June, .      | 82,400                                                              | 69                      | 67        | 40m.                                                                  | V. slight.  | .10    | 0.0340   | .0234       | 13.07     | 4.27        | .0025     | 0.23             | 1,036                          |
| July, .      | 77,000                                                              | 69                      | 72        | 49m.                                                                  | None.       | .12    | 0.0203   | .0204       | 3.44      | 3.84        | .0004     | 0.21             | 614                            |
| August, .    | 57,800                                                              | 70                      | 72        | 42m.                                                                  | None.       | .11    | 0.0302   | .0221       | 16.39     | 3.42        | .0025     | 0.22             | 2,486                          |
| September, . | 60,000                                                              | 67                      | 71        | 9m.                                                                   | None.       | .11    | 0.0209   | .0219       | 15.37     | 4.30        | .0010     | 0.23             | 519                            |
| October, .   | 44,400                                                              | 55                      | 61        | 39m.                                                                  | V. slight.  | .12    | 0.1051   | .0208       | 9.97      | 2.78        | .0020     | 0.23             | 2,299                          |
| November, .  | 48,400                                                              | 52                      | 50        | 25m.                                                                  | None.       | .13    | 0.1694   | .0324       | 7.92      | 3.19        | .0113     | 0.23             | 3,850                          |
| December, .  | 55,400                                                              | 46                      | 42        | 20m.                                                                  | Slight.     | .34    | 1.0200   | .0835       | 8.08      | 1.56        | .0588     | 0.60             | 7,661                          |

Sewage applied, 400 gallons six times a week, January 1 to July 31; 300 gallons six times a week, August 1 to October 21; 150 gallons three times a week, October 22 to 31; 300 gallons six times a week, November 1 to December 31. April 11 to 20, experiment interrupted by freshet. Tank covered with canvas February 1 to March 13. Effluent pipe plugged August 30 and 31, and August 31 to September 4. A trap 18 inches high attached to outlet pipe August 31 to September 14. September 9, trap turned down and pipe flushed out. Surface raked 1 inch deep each week, except once in January and twice in February. March 23, surface spaded 4 inches deep; August 20, 3 inches deep; September 7, October 22 and November 8, 6 inches deep; November 20, 3 inches deep. During January, 15 inches of snow, and 8½ inches of ice removed from surface; during February, 1 inch of ice removed; during March, 2½ inches of snow removed; during December, 8 inches of snow and 2 inches of ice removed.

*Filter No. 10.*

This filter, one two-hundredth of an acre in area, contains 5 feet in depth of a mixed coarse and fine sand of an effective size of 0.35 millimeter. No gravel or under-drains are beneath the sand except directly above and around the outlet pipe. A partition extending 3 feet below the surface separates that quarter of the surface farthest removed from the under-drains from the remainder of the surface. To this quarter of the surface farthest from the under-drains the sewage is applied and, during January, the rate of application was 160,000 gallons per acre daily. The filter had not rested during November, 1894, and nitrification was fairly active but steadily decreased and the free ammonia of the effluent was high. The applied

sewage contained a large percentage of organic matter in suspension, and this, together with the extremely cold weather and the consequent depth of frost in the filter, clogged the surface of the filter to such a degree that the applied sewage was disposed of with difficulty, and on February 1 the rate of application was reduced to 80,000 gallons per acre daily and increased to 160,000 gallons per acre daily April 1. The character of the effluent deteriorated, however, during February, but improved rapidly in March and was fairly satisfactory during the remainder of the year. During the winter the sewage was applied to a trench 1 foot in depth and on March 23 this trench was filled and the surface of the filter levelled. Later in the spring it seemed probable that sub-surface clogging was taking place in the filter, and the quarter of the surface to which sewage is applied was dug over to the depth of 18 inches on May 18. This was followed by greatly improved nitrification. On October 22 the surface of the filter to which sewage is applied was spaded over to the depth of 6 inches. The following table gives the results of the monthly averages of the weekly analyses:—

*Monthly Averages of Analyses of Effluent of Filter No. 10.*

[Parts per 100,000.]

| 1895.        | Quantity<br>Applied<br><br>Gallons<br>per Acre<br>Daily for Six<br>Days in a<br>Week. | TEMPERA-<br>TURE.<br><br>DEG. F. |           | Length of<br>Time<br>Sewage<br>Remained<br>on<br>Surface.<br><br>Hours and<br>Minutes. | APPEARANCE. |        | AMMONIA. |             | NITROGEN<br>AS |           | Oxygen Consumed. | Bacteria per<br>Cubic<br>Centimeter. |           |
|--------------|---------------------------------------------------------------------------------------|----------------------------------|-----------|----------------------------------------------------------------------------------------|-------------|--------|----------|-------------|----------------|-----------|------------------|--------------------------------------|-----------|
|              |                                                                                       | Sewage.                          | Effluent. |                                                                                        | Turbidity.  | Color. | Free.    | Albuminoid. | Chlorine.      | Nitrates. |                  |                                      | Nitrites. |
|              |                                                                                       |                                  |           |                                                                                        |             |        |          |             |                |           |                  |                                      |           |
| January, .   | 160,000                                                                               | 40                               | 37        | 12h 34m.                                                                               | Decided.    | .40    | 1.9200   | .0936       | 7.79           | .86       | .0128            | .63                                  | 98,200    |
| February, .  | 80,000                                                                                | 47                               | 35        | 12h. -                                                                                 | Decided     | .71    | 2.6500   | .1075       | 8.65           | .31       | .0112            | .83                                  | 39,100    |
| March, .     | 80,000                                                                                | 45                               | 37        | 58m.                                                                                   | V. slight.  | .44    | 1.3550   | .0710       | 7.27           | 1.82      | .0085            | .51                                  | 22,950    |
| April, .     | 160,000                                                                               | 47                               | 42        | 38m.                                                                                   | V. slight.  | .14    | .3100    | .0400       | 8.79           | 2.22      | .0175            | .28                                  | 6,833     |
| May, .       | 160,000                                                                               | 58                               | 56        | 7h. -                                                                                  | Slight.     | .27    | .1533    | .0467       | 13.79          | 1.90      | .0027            | .41                                  | 5,935     |
| June, .      | 160,000                                                                               | 69                               | 65        | 2m.                                                                                    | Slight.     | .20    | .3100    | .0440       | 14.12          | 3.71      | .0035            | .36                                  | 6,384     |
| July, .      | 160,000                                                                               | 70                               | 71        | 1m.                                                                                    | V. slight.  | .12    | .1073    | .0193       | 15.06          | 3.42      | .0013            | .21                                  | 518       |
| August, .    | 160,000                                                                               | 70                               | 71        | 5m.                                                                                    | None.       | .07    | .0115    | .0150       | 13.87          | 3.63      | .0003            | .16                                  | 177       |
| September, . | 160,000                                                                               | 67                               | 70        | 6m.                                                                                    | None.       | .08    | .0404    | .0177       | 13.73          | 3.84      | .0040            | .17                                  | 205       |
| October, .   | 160,000                                                                               | 55                               | 61        | 7m.                                                                                    | None.       | .07    | .0222    | .0146       | 10.02          | 3.12      | .0041            | .14                                  | 199       |
| November, .  | 160,000                                                                               | 51                               | 52        | 8h. 56m.                                                                               | None.       | .08    | .1195    | .0177       | 7.81           | 2.36      | .0533            | .20                                  | 1,570     |
| December, .  | 160,000                                                                               | 45                               | 44        | 8m.                                                                                    | V. slight.  | .17    | .8875    | .0625       | 7.78           | 1.92      | .2813            | .36                                  | 4,885     |

Sewage applied, 200 gallons six times a week, January 1 to 31; 100 gallons six times a week, February 1 to March 31; 200 gallons six times a week, April 1 to July 31; 160 gallons six times a week, August 1 to October 22; 75 gallons three times a week, October 23 to 31; 160 gallons six times a week, November 1 to December 31. April 11 to 20, experiment interrupted by a freshet. August 31 to September 6, a trap 18 inches high was attached to outlet pipe. October 12, grass and weeds removed from that part of surface which is not flooded, and sand dug over 6 inches deep. That part of the surface to which sewage is applied has been raked once each week, except once in January and twice in February. May 18, that part of surface to which sewage is applied was spaded over 18 inches deep; August 9, 8 inches deep; October 22, 6 inches deep; December 27, 8 inches deep. During January, 16½ inches of snow and 3 inches of ice removed from that part of surface to which sewage is applied; during February, 30½ inches of snow and 5½ inches of ice removed; during March, 5½ inches of snow removed; during April, ¼ inch of snow removed; during December, 8 inches of snow and ¾ inch of ice removed.

*Filters Nos. 12 A, 15 B and 16 B.*

Filter No. 12 A contains 60 inches in depth of sand of an effective size of 0.19 millimeter, and filters Nos. 15 B and 16 B contain 65 inches in depth of gravel stones of an effective size of 5.40 millimeters. These three filters were first put in operation in July, 1892, and the effluents of filters Nos. 15 B and 16 B have uniformly been applied to Filter No. 12 A.

The actual rates of filtration in gallons per acre daily of these three filters during their period of operation up to Jan. 1, 1896, have been as follows:—

|                                             | 1892.   | 1893.   | 1894.   | 1895.   |
|---------------------------------------------|---------|---------|---------|---------|
| Filter No. 15 B, . . . . .                  | 206,000 | 405,000 | 474,000 | 449,000 |
| Filter No. 16 B, . . . . .                  | 206,000 | 432,000 | 463,000 | 465,000 |
| Filter No. 12 A, . . . . .                  | 411,000 | 745,000 | 700,500 | 641,000 |
| Average rate for the combined area, . . . . | 137,000 | 248,300 | 233,500 | 214,000 |

Since the first part of 1893, filtration in filters Nos. 15 B and 16 B has been aided by a current of air drawn down through the filters. It is seen from the table above that Filter No. 12 A has not been able to take the entire volume of effluent of the gravel-stone filters during the past three years, and that its quantitative capacity has gradually decreased. Beginning March 24, 1893, the surface of Filter No. 12 A was scraped on an average once in five days during the year, to relieve clogging, and the average depth of sand removed at each scraping was 0.24 inch. The removed sand was washed and replaced. From Jan. 1, 1894, to June 19, 1894, the surface of this filter was scraped whenever necessary, to remove clogging, and the removed sand was not replaced.

The average interval between scrapings up to June 19 was seventeen days, and the average depth scraped was 0.17 of an inch, equivalent to 12 cubic yards of material removed per 1,000,000 gallons of partially purified sewage filtered. From this date until the end of 1894 the surface was raked to a depth of 3 inches twice each week and spaded over 6 inches deep September 6 and October 27, and 8 inches deep on November 21. The filter was in good condition at the beginning of 1895 and the same method of treatment

was continued, the surface being raked to a depth of 3 inches twice each week during the year and spaded over to a depth of 6 inches March 15, May 25, July 17 and August 3. Towards the end of September the filter began to be badly clogged, and was spaded over to a depth of 6 inches six times between September 21 and November 1, and to a depth of 8 inches seven times between November 1 and December 12. The quantitative capacity of the filter steadily decreased however, and on December 7 the surface sand to a depth of 7 inches was removed, washed and replaced. This sand, before washing, contained 76.10 parts of nitrogen by weight in 100,000 parts of dry sand, and after washing, 7.90 parts. Following this treatment the applied sewage was disposed of more readily. It seems probable that though the organic matters stored in the sand are not present in large quantities, they are of a fatty nature not easily acted upon bacterially; are, in fact, the organic matters that have been partially worked over while passing through the gravel filters and the more easily attacked portion removed. The effluent of Filter No. 12 A has been of most excellent quality throughout the year.

Filters Nos. 15 B and 16 B have received sewage during their period of operation at the rate in gallons per acre daily given in the preceding table. From the time the aspirators were attached to the filters until Sept. 1, 1894, a current of air was constantly drawn down through the filters at the rate of about one gallon in every four minutes. At this date the method of aëration was changed, so that the filters were aerated only at night for twelve or sixteen hours. Better results followed this method of aëration, and the volume of air supplied was sufficient, as shown by examination of the effluents for dissolved oxygen, it being almost uniformly present. The surfaces of these two filters were not disturbed until July, 1893, a year after they were first put in operation, but since that date they have been raked and spaded over very often. During 1895 they have been raked over once each week to a depth of 3 inches and spaded over 6 or 8 inches deep when the condition of the surface required it. There has been an accumulation of organic matter in the filters each year, and to such an extent that, in order to continue them in service, Filter No. 15 B had to be flushed out twice during 1894 by applying city water under pressure for six hours to the outlet pipe, the wash water flowing away over the top of the filter. Filter No. 16 B was given a similar flushing out during 1894, and later the

filtering material was entirely removed and replaced after washing. February 1, 1895, the entire filtering material of Filter No. 15 B was removed, washed and replaced, and after the high water of the Merrimack River in April, the upper 6 inches of gravel in both filters was removed and washed, to free it from river silt. The aspirator of Filter No. 16 B has been allowed to run from nine P.M. to five A.M. each night during the year, and that of 15 B for the same hours until September 2, since when it has been allowed to run from nine to eleven P.M. Aëration for two hours has sufficed to give a good effluent, but there has undoubtedly been a larger percentage of organic matter stored in the filter than there would have been with longer continued aeration each day. In conclusion it seems reasonable to say that the rate of application of sewage and the period of aëration should be so defined that flushing out the filters, or removing and washing the filtering material, would seldom be necessary, as these operations in themselves create a very large volume of sewage to be in some manner disposed of.

The quality of the effluents of these filters during 1895 is shown by the following tables :—

*Monthly Averages of Analyses of Effluent of Filter No. 12 A.*

[Parts per 100,000.]

| 1895.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage Remained on Surface.<br>Hours and Minutes. | APPEARANCE. |        | AMMONIA. |             | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |           |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|------------------------------------------------------------------|-------------|--------|----------|-------------|-------------|-----------|------------------|--------------------------------|-----------|
|              |                                                                     | Sewage.                 | Effluent. |                                                                  | Turbidity.  | Color. | Free.    | Albuminoid. | Chlorine.   | Nitrates. |                  |                                | Nitrites. |
| January, .   | 620,000                                                             | 42                      | 45        | 2h. 31m.                                                         | V. slight.  | .19    | .0014    | .0282       | 7.75        | 2.57      | .0000            | .29                            | 1,670     |
| February, .  | 590,000                                                             | 41                      | 43        | 3h. -                                                            | V. slight.  | .24    | .1030    | .0290       | 8.05        | 2.27      | .0015            | .37                            | 2,866     |
| March, .     | 701,000                                                             | 44                      | 48        | 2h. 45m.                                                         | V. slight.  | .26    | .0109    | .0288       | 10.12       | 2.12      | .0002            | .37                            | 2,145     |
| April, .     | 402,000                                                             | 47                      | 50        | 2h. 19m.                                                         | None.       | .27    | .0019    | .0277       | 11.07       | 2.51      | .0000            | .36                            | 676       |
| May, .       | 804,000                                                             | 58                      | 56        | 2h. 31m.                                                         | V. slight.  | .26    | .0013    | .0282       | 12.25       | 1.32      | .0000            | .33                            | 606       |
| June, .      | 835,000                                                             | 68                      | 68        | 1h. 19m.                                                         | None.       | .27    | .0012    | .0275       | 16.27       | 1.46      | .0000            | .33                            | 474       |
| July, .      | 837,000                                                             | 69                      | 69        | 2h. 32m.                                                         | None.       | .22    | .0008    | .0257       | 18.53       | 1.94      | .0000            | .30                            | 377       |
| August, .    | 855,000                                                             | 71                      | 71        | 2h. 22m.                                                         | None.       | .19    | .0012    | .0206       | 14.43       | 2.60      | .0000            | .27                            | 123       |
| September, . | 874,000                                                             | 67                      | 65        | 2h. 35m.                                                         | None.       | .17    | .0013    | .0237       | 16.71       | 3.44      | .0000            | .23                            | 310       |
| October, .   | 408,000                                                             | 56                      | 56        | 3h. 22m.                                                         | None.       | .34    | .0046    | .0249       | 12.12       | 2.35      | .0003            | .25                            | 1,566     |
| November, .  | 234,000                                                             | 54                      | 54        | 3h. 30m.                                                         | None.       | .17    | .0098    | .0340       | 8.76        | 2.40      | .0005            | .18                            | 971       |
| December, .  | 411,000                                                             | 50                      | 53        | 3h. -                                                            | None.       | .19    | .0010    | .0222       | 8.69        | 1.81      | .0002            | .26                            | 966       |

Effluent of filters Nos. 15 and 16 applied 24 times a week, January 1 to July 9; thirty times a week, July 10 to August 2; twenty-four times a week, August 3 to September 21; thirty times a week, September 22 to November 7; none applied October 18 to 26; once a week, November 8 to 24; twenty-four times a week, November 25 to December 31. April 11 to 24, experiment interrupted by freshet. Surface raked 3 inches deep twice each week. February 16, 6 inches of sand removed; sand replaced in tank March 1. February 18 and August 3,  $\frac{1}{2}$  inch of sand removed. Sand disturbed 6 inches deep on following dates: February 16, March 15, May 25, July 17, August 3, September 21, October 5, 10, 12, 18 and 28. Sand disturbed 8 inches deep on the following dates: November 8, 11, 15, 18, 22, 29 and December 2. December 7, 7 inches of sand removed, washed and replaced in tank.

*Monthly Averages of Analyses of Effluent of Filter No. 15 B.*

[Parts per 100,000.]

| 1895.        | Quantity<br>Applied.<br><br>Gallons.<br>per Acre<br>Daily for Six<br>Days in a<br>Week. | TEMPERA-<br>TURE.<br>DEG. F. |           | Length of<br>Time<br>Sewage<br>Remained<br>on<br>Surface.<br><br>Hours and<br>Minutes. | APPEARANCE. |        | AMMONIA. |             | NITROGEN<br>AS |           | Oxygen Consumed. | Bacteria per<br>Cubic<br>Centimeter. |           |
|--------------|-----------------------------------------------------------------------------------------|------------------------------|-----------|----------------------------------------------------------------------------------------|-------------|--------|----------|-------------|----------------|-----------|------------------|--------------------------------------|-----------|
|              |                                                                                         | Sewage.                      | Effluent. |                                                                                        | Turbidity.  | Color. | Free.    | Albuminoid. | Chlorine.      | Nitrates. |                  |                                      | Nitrites. |
|              |                                                                                         |                              |           |                                                                                        |             |        |          |             |                |           |                  |                                      |           |
| January, .   | 310,000                                                                                 | 47                           | 43        | 25m.                                                                                   | Decided.    | .58    | 1.1775   | .1920       | 7.89           | 2.15      | .0147            | 1.13                                 | 236,200   |
| February, .  | 452,000                                                                                 | 46                           | 42        | None.                                                                                  | Decided.    | .85    | 2.0575   | .3150       | 8.38           | 1.33      | .0043            | 1.95                                 | 167,000   |
| March, .     | 480,000                                                                                 | 47                           | 45        | None.                                                                                  | Great.      | .66    | 1.0100   | .1715       | 10.86          | 2.21      | .0170            | 1.41                                 | 142,000   |
| April, .     | 303,000                                                                                 | 51                           | 48        | None.                                                                                  | Great.      | .55    | 0.3650   | .1250       | 8.64           | 2.02      | .0161            | 1.12                                 | 101,000   |
| May, .       | 480,000                                                                                 | 62                           | 57        | None.                                                                                  | Decided.    | .45    | 0.7136   | .1300       | 15.33          | 1.10      | .0272            | 0.90                                 | 192,000   |
| June, .      | 499,000                                                                                 | 72                           | 68        | None.                                                                                  | Decided.    | .43    | 0.4375   | .1270       | 14.45          | 1.74      | .0058            | 0.95                                 | 221,000   |
| July, .      | 462,000                                                                                 | 71                           | 68        | None.                                                                                  | Decided.    | .58    | 1.4000   | .2250       | 17.96          | 1.83      | .0133            | 1.55                                 | 585,000   |
| August, .    | 480,000                                                                                 | 73                           | 71        | None.                                                                                  | Great.      | .43    | 0.7067   | .0805       | 14.60          | 2.14      | .0093            | 0.76                                 | 266,000   |
| September, . | 480,000                                                                                 | 69                           | 66        | None.                                                                                  | Great.      | .56    | 1.0000   | .1825       | 15.28          | 2.50      | .1025            | 1.14                                 | 482,000   |
| October, .   | 480,000                                                                                 | 56                           | 55        | None.                                                                                  | Decided.    | .42    | 1.0000   | .1573       | 11.16          | 2.35      | .0987            | 0.94                                 | 364,000   |
| November, .  | 480,000                                                                                 | 54                           | 55        | None.                                                                                  | Great.      | .52    | 0.8333   | .1773       | 10.30          | 1.54      | .4800            | 1.30                                 | 482,000   |
| December, .  | 480,000                                                                                 | 45                           | 51        | None.                                                                                  | Decided.    | .63    | 0.9533   | .1733       | 11.41          | 1.75      | .0230            | 1.23                                 | 709,000   |

Sewage applied, 2 gallons seventy-two times a week. No sewage applied, January 4 to 10, January 28 to February 1. April 10 to 20, experiment interrupted by freshet. Filter was aspirated sixteen hours each night, January 1 to March 2, except from January 4 to 10, and January 28 to February 1, when aspirator was run continuously; eight hours a day, March 4 to May 13; fifteen minutes a day, May 14 to June 4; one hour a day, June 6 to 12; eight hours a day, June 13 to August 31; two hours a day, September 2 to December 31. February 1, all the gravel taken out of tank, washed and replaced. March 2, 5 inches of gravel removed from tank. April 20, 6 inches of gravel removed from tank, washed and replaced. Surface raked 3 inches deep once a week. Surface spaded 12 inches deep January 30. December 14, under-drains washed out with city pressure.

*Monthly Averages of Analyses of Effluent of Filter No. 16 B.*

[Parts per 100,000.]

| 1895.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage Remained on Surface.<br>Hours and Minutes. | APPEARANCE. |        | AMMONIA. |             | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |           |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|------------------------------------------------------------------|-------------|--------|----------|-------------|-------------|-----------|------------------|--------------------------------|-----------|
|              |                                                                     | Sewage.                 | Effluent. |                                                                  | Turbidity.  | Color. | Free.    | Albuminoid. | Chlorine.   | Nitrates. |                  |                                | Nitrites. |
|              |                                                                     |                         |           |                                                                  |             |        |          |             |             |           |                  |                                |           |
| January, .   | 480,000                                                             | 47                      | 41        | 10m.                                                             | Decided.    | .42    | 0.5480   | .1552       | 8.43        | 1.84      | .0116            | 1.01                           | 410,000   |
| February, .  | 480,000                                                             | 46                      | 39        | None.                                                            | Decided.    | .52    | 0.6200   | .1730       | 8.33        | 1.91      | .0092            | 1.19                           | 263,800   |
| March, .     | 480,000                                                             | 47                      | 43        | None.                                                            | Great.      | .40    | 0.2850   | .1100       | 10.48       | 1.44      | .0075            | 0.86                           | 185,000   |
| April, .     | 303,000                                                             | 51                      | 47        | None.                                                            | Great.      | .35    | 0.2200   | .1110       | 9.87        | 1.49      | .0090            | 0.85                           | 156,000   |
| May, .       | 480,000                                                             | 62                      | 57        | None.                                                            | Decided.    | .28    | 0.3700   | .1072       | 14.42       | 1.82      | .0120            | 0.66                           | 267,000   |
| June, .      | 499,000                                                             | 72                      | 67        | None.                                                            | Great.      | .65    | 1.0700   | .1815       | 11.35       | 0.49      | .0045            | 1.34                           | 677,000   |
| July, .      | 462,000                                                             | 71                      | 69        | 30m.                                                             | Great.      | .68    | 0.7680   | .1348       | 17.36       | 1.47      | .0092            | 0.84                           | 451,000   |
| August, .    | 480,000                                                             | 73                      | 71        | None.                                                            | Decided.    | .31    | 0.7800   | .1340       | 14.48       | 1.98      | .0098            | 0.93                           | 341,000   |
| September, . | 480,000                                                             | 69                      | 65        | None.                                                            | Decided.    | .43    | 1.3125   | .2400       | 15.22       | 0.89      | .0220            | 1.27                           | 654,000   |
| October, .   | 480,000                                                             | 56                      | 56        | None.                                                            | Decided.    | .31    | 0.3325   | .1590       | 11.28       | 1.19      | .0750            | 0.97                           | 656,000   |
| November, .  | 480,000                                                             | 54                      | 52        | None.                                                            | Decided.    | .40    | 0.8767   | .1847       | 9.80        | 0.99      | .3267            | 1.15                           | 657,000   |
| December, .  | 480,000                                                             | 45                      | 48        | None.                                                            | Decided.    | .49    | 1.1000   | .1807       | 11.30       | 1.24      | .0207            | 1.19                           | 1,060,000 |

Sewage applied, 2 gallons seventy-two times a week. April 10 to 20, experiment interrupted by freshet. Filter aspirated eight hours each night. September 2 to 26, aspirator run at one-quarter regular speed. March 2, 5 inches of gravel removed from tank. April 20, 6 inches of gravel removed from tank, washed and replaced. December 14, under-drains washed out with city pressure. Surface raked 3 inches deep once a week.

*Filter No. 13 A.*

This filter contains 60 inches in depth of medium fine sand of an effective size of 0.19 millimeter, and has received the supernatant liquid from sewage which has been allowed to settle for four hours.

The rate of filtration during the greater part of 1895 has been approximately 160,000 gallons per acre daily. The filter was in good condition at the beginning of the year and was raked to a depth of 3 inches twice each week during the year and spaded over to a depth of 6 inches March 15, July 5, August 24, September 4 and 22, and October 4, 18 and 28. During the first eight months of the year nitrification was active in the filter although the effluent contained free ammonia in considerable quantity, but during September the nitrates of the effluent rapidly decreased and the filter was spaded over repeatedly to a depth of 6 inches, as noted above, but without appreciable effect upon the character of the effluent. On October 28 the gravel under-drains of the filter were flushed out with city water and a large amount of iron which had been deposited upon the gravel was in this way removed. Following this treatment the quality of the effluent rapidly improved, and during November and December the nitrates were the highest and the ammonias the lowest of the year. It seems probable that during September and October there was good nitrification within the filter but that the nitrates of the effluent were reduced to free ammonia while passing through the under-drains of the filter. The following table gives the monthly averages of the weekly analyses:—

*Monthly Averages of Analyses of Effluent of Filter No. 13 A.*

[Parts per 100,000.]

| 1895.        | Quantity Applied.<br>Gallons per Acre Daily for six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage Remained on Surface.<br>Hours and Minutes. | APPEARANCE. |        | AMMONIA. |             | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |           |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|------------------------------------------------------------------|-------------|--------|----------|-------------|-------------|-----------|------------------|--------------------------------|-----------|
|              |                                                                     | Sewage.                 | Effluent. |                                                                  | Turbidity.  | Color. | Free.    | Albuminoid. | Chlorine.   | Nitrates. |                  |                                | Nitrites. |
| January, .   | 160,000                                                             | 4                       | 44        | 48m.                                                             | V. slight.  | .17    | 0.3140   | .0252       | 9.10        | 2.23      | .0029            | .25                            | 3,020     |
| February, .  | 160,000                                                             | 46                      | 42        | 1h. 43m.                                                         | Slight.     | .37    | 0.5167   | .0493       | 8.96        | 1.58      | .0053            | .38                            | 13,730    |
| March, .     | 147,700                                                             | 47                      | 47        | 2h. 10m.                                                         | Decided.    | .69    | 1.5350   | .0950       | 9.15        | 1.62      | .0161            | .93                            | 46,759    |
| April, .     | 160,000                                                             | 51                      | 50        | 19m.                                                             | V. slight.  | .12    | 0.0940   | .0230       | 9.79        | 3.25      | .0019            | .20                            | 1,904     |
| May, .       | 160,000                                                             | 62                      | 56        | 12m.                                                             | V. slight.  | .10    | 0.1259   | .0201       | 10.84       | 2.42      | .0006            | .18                            | 427       |
| June, .      | 166,000                                                             | 72                      | 67        | 1h. 58m.                                                         | V. slight.  | .29    | 0.3500   | .0440       | 87          | 1.62      | .0050            | .30                            | 1,146     |
| July, .      | 154,000                                                             | 71                      | 67        | 40m.                                                             | V. slight.  | .47    | 0.7125   | .0585       | 5.24        | 1.41      | .0026            | .53                            | 908       |
| August, .    | 154,000                                                             | 73                      | 71        | 3h. 37m.                                                         | V. slight.  | .22    | 0.2453   | .0313       | 15.25       | 2.05      | .0090            | .27                            | 1,190     |
| September, . | 153,600                                                             | 69                      | 66        | 4h. 25m.                                                         | Decided.    | red    | 0.8367   | .1293       | 13.55       | 0.59      | .0123            | .89                            | 4,607     |
| October, .   | 47,400                                                              | 56                      | 56        | 8h. -                                                            | Slight.     | red    | 1.9900   | .1055       | 12.72       | 0.10      | .0160            | .83                            | 2,283     |
| November, .  | 157,000                                                             | 54                      | 55        | 13m.                                                             | None.       | .10    | 0.1260   | .0313       | 8.04        | 3.06      | .1712            | .25                            | 3,215     |
| December, .  | 160,000                                                             | 45                      | 52        | 9m.                                                              | None.       | .09    | 0.0043   | .0161       | 8.48        | 3.59      | .0021            | .10                            | 568       |

Settled sewage applied, 4 gallons twelve times a week. No sewage applied, October 17 to November 1. April 10 to 22, experiment interrupted by freshet. Surface raked 3 inches deep twice each week. Surface dug over 6 inches deep on the following dates: March 15, July 5, August 24, September 4, 22, October 4, 12, 18 and 23. October 23, under-drains washed out with city pressure.

*Filter No. 14 A.*

This filter contains 60 inches in depth of medium fine sand of an effective size of 0.19 millimeter, and has received since June 1, 1894, sewage which has been strained through a shallow layer of coke. This partially purified sewage has been applied to the filter at an average rate, excluding periods of rest, of 320,000 gallons per acre daily during the year. The surface of the filter has been raked to a depth of 3 inches twice each week during the year and spaded over to a depth of 6 inches, March 15, August 24 and October 6. The quality of the effluent has been satisfactory throughout the year and has invariably contained high nitrates. The filter was in excellent condition at the end of the year. The following table gives the monthly summary of the analyses made during the year:—

*Monthly Averages of Analyses of Effluent of Filter No. 14 A.*

[Parts per 100,000.]

| 1895.       | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage Remained on Surface.<br>—<br>Hours and Minutes. | APPEARANCE. |        | AMMONIA. |             | NITROGEN AS |           |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|-------------|---------------------------------------------------------------------|-------------------------|-----------|-----------------------------------------------------------------------|-------------|--------|----------|-------------|-------------|-----------|-----------|------------------|--------------------------------|
|             |                                                                     | Sewage.                 | Effluent. |                                                                       | Turbidity.  | Color. | Free.    | Albuminoid. | Chlorine.   | Nitrates. | Nitrites. |                  |                                |
| January, .  | 320,000                                                             | 47                      | 43        | 33m.                                                                  | V. slight.  | .14    | 0.2187   | .0285       | 7.76        | 2.49      | .0029     | .23              | 5,190                          |
| February, . | 317,000                                                             | 46                      | 42        | 1h. 42m.                                                              | Slight.     | .43    | 1.7300   | .0660       | 8.40        | 1.42      | .0011     | .61              | 2,770                          |
| March, .    | 295,000                                                             | 47                      | 45        | 1h. 26m.                                                              | Slight.     | .34    | 1.0870   | .0415       | 8.82        | 1.72      | .0133     | .43              | 11,909                         |
| April, .    | 320,000                                                             | 51                      | 48        | 58m.                                                                  | Slight.     | .50    | 1.5750   | .0720       | 10.06       | 1.26      | .0036     | .51              | 9,800                          |
| May, .      | 320,000                                                             | 62                      | 56        | 13m.                                                                  | None.       | .13    | 0.0435   | .0270       | 13.13       | 2.66      | .0048     | .20              | 1,424                          |
| June, .     | 333,000                                                             | 72                      | 68        | 19m.                                                                  | None.       | .13    | 0.0527   | .0248       | 19.96       | 2.55      | .0022     | .23              | 317                            |
| July, .     | 308,000                                                             | 71                      | 67        | 16m.                                                                  | None.       | .10    | 0.0119   | .0223       | 17.73       | 3.12      | .0004     | .21              | 296                            |
| August, .   | 311,000                                                             | 73                      | 70        | 38m.                                                                  | None.       | .21    | 0.2438   | .0305       | 16.86       | 3.00      | .0014     | .32              | 253                            |
| September,  | 320,000                                                             | 69                      | 65        | 19m.                                                                  | None.       | .13    | 0.0066   | .0229       | 14.32       | 3.74      | .0003     | .22              | 122                            |
| October, .  | 207,000                                                             | 56                      | 55        | 14m.                                                                  | None.       | .14    | 0.0190   | .0145       | 13.90       | 2.82      | .0025     | .21              | 233                            |
| November,   | 314,000                                                             | 54                      | 52        | 15m.                                                                  | None.       | .15    | 0.1208   | .0358       | 8.49        | 2.67      | .0013     | .22              | 345                            |
| December,   | 320,000                                                             | 45                      | 50        | 19m.                                                                  | V. slight.  | .19    | 0.0025   | .0274       | 8.21        | 3.32      | .0005     | .25              | 1,657                          |

Four gallons of sewage, strained through coke, applied twenty-four times a week. No sewage applied October 21 to November 1. April 10 to 20, experiment interrupted by freshet. Surface raked 3 inches deep twice each week. Surface dug over 6 inches deep on the following dates: March 15, August 24, October 4, 21 and 28.



*Filter No. 19.*

This filter contains 60 inches in depth of medium fine sand of an effective size of 0.19 millimeter, and has received the supernatant liquid from sewage which has been allowed to settle four hours after treatment with sulphate of alumina at the rate of 1,000 pounds per 1,000,000 gallons. The filter has received this supernatant liquid since Jan. 20, 1893, and the rate of application during 1895 has been, excluding periods of rest, 200,000 gallons per acre daily. Nitrification has been very active in the filter during the entire year, as shown by the high nitrates of the effluent. The albuminoid ammonia of the effluent was comparatively low during the year, and the comparatively high free ammonia was not caused by any clogging of the filter but was the natural consequence of the extremely high free ammonia of the applied sewage. The filter was raked 3 inches deep each week and spaded over 6 inches deep October 28.

*Monthly Averages of Analyses of Effluent of Filter No. 19 A.*

[Parts per 100,000.]

| 1895:       | Quantity Applied.<br><br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time Sewage Remained on Surface.<br><br>Hours and Minutes. | APPEARANCE. |        | AMMONIA. |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|-------------|-------------------------------------------------------------------------|-------------------------|-----------|----------------------------------------------------------------------|-------------|--------|----------|------------|-----------|-------------|-----------|------------------|--------------------------------|
|             |                                                                         | Sewage.                 | Effluent. |                                                                      | Turbidity.  | Color. | Free.    | Albuminoid |           | Nitrates.   | Nitrites. |                  |                                |
| January, .  | 200,000                                                                 | 47                      | 40        | 38m.                                                                 | V. slight.  | .13    | .4940    | .0288      | 7.24      | 2.19        | .1160     | .36              | 3,770                          |
| February, . | 200,000                                                                 | 46                      | 38        | 6h. 27m.                                                             | Slight.     | .16    | .7500    | .0507      | 9.14      | 1.76        | .0967     | .43              | 3,570                          |
| March, .    | 200,000                                                                 | 47                      | 42        | 1h. 11m.                                                             | V. slight.  | .15    | .4325    | .0265      | 7.66      | 2.09        | .0850     | .39              | 1,622                          |
| April, .    | 200,000                                                                 | 51                      | 47        | 35m.                                                                 | V. slight.  | .15    | .4750    | .0380      | 11.99     | 2.90        | .0425     | .36              | 1,820                          |
| May, .      | 200,000                                                                 | 62                      | 60        | 22m.                                                                 | None.       | .14    | .5000    | .0295      | 11.04     | 2.93        | .0413     | .30              | 422                            |
| June, .     | 208,000                                                                 | 72                      | 67        | 16m.                                                                 | V. slight.  | .17    | .9160    | .0525      | 16.55     | 4.42        | .0083     | .34              | 117                            |
| July, .     | 193,000                                                                 | 71                      | 67        | 13m.                                                                 | None.       | .16    | .5175    | .0415      | 15.08     | 3.94        | .0004     | .35              | 664                            |
| August, .   | 196,000                                                                 | 73                      | 70        | 14m.                                                                 | V. slight.  | .14    | .1847    | .0260      | 15.26     | 3.52        | .0001     | .29              | 469                            |
| September,  | 200,000                                                                 | 69                      | 63        | 15m.                                                                 | None.       | .13    | .1474    | .0254      | 13.92     | 3.58        | .0001     | .23              | 125                            |
| October, .  | 170,000                                                                 | 56                      | 57        | 13m.                                                                 | None.       | .14    | .3550    | .0260      | 12.29     | 3.74        | .0000     | .28              | 69                             |
| November,   | 196,000                                                                 | 54                      | 50        | 16m.                                                                 | None.       | .12    | .1720    | .0313      | 8.30      | 3.39        | .0167     | .27              | 92                             |
| December,   | 200,000                                                                 | 45                      | 47        | 19m.                                                                 | None.       | .11    | .4767    | .0353      | 8.82      | 3.21        | .0017     | .24              | 319                            |

Chemically precipitated sewage applied, 5 gallons twelve times each week. No sewage applied October 28 to November 1. April 10 to 20, experiment interrupted by freshet. Surface raked 3 inches deep twice each week. October 28, surface dug over 6 inches deep.

*Filter No. 21 A.*

This filter was started March 19, 1894. A portion of the filtering material was removed during 1894, but on April 1, 1895, the filter was restored to its original depth of 60 inches of fine sifted gravel of an effective size of 1.60 millimeters. Since July 7, 1894, it has had a current of air drawn downward through it, at the rate of about one gallon in four minutes, for ten or twelve hours each night. During 1895 this filter has received sewage during its period of actual operation at the rate of 360,000 gallons per acre daily, except during June and July, when the rate of application was 499,000 and 427,000 gallons per acre daily, respectively. The filter became badly clogged during February and was allowed to rest from February 18 to April 1, with continual aëration. This treatment improved the condition of the filter and restored nitrification. In August clogging again occurred and the filter was allowed to rest, with continuous aëration from August 7 to 21 inclusive. During the remainder of the year the filter was in good condition. The following table gives the results of the monthly averages of the weekly analyses:—

*Monthly Averages of Analyses of Effluent of Filter No 21 A.*

[Parts per 100,000.]

| 1895.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | Average Number of Applications which Remained on Surface less than 30 Minutes. | APPEARANCE. |        | AMMONIA. |             | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |           |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|--------------------------------------------------------------------------------|-------------|--------|----------|-------------|-------------|-----------|------------------|--------------------------------|-----------|
|              |                                                                     | Sewage.                 | Effluent. |                                                                                | Turbidity.  | Color. | Free.    | Albuminoid. | Chlorine.   | Nitrates. |                  |                                | Nitrites. |
| January, .   | 310,000                                                             | 47                      | 42        | 2                                                                              | Decided.    | 0.46   | 1.1700   | .1600       | 8.19        | 2.89      | .0814            | 0.85                           | 262,000   |
| February, .  | 243,000                                                             | 46                      | 38        | 10                                                                             | Decided.    | 1.30   | 2.7750   | .3250       | 8.59        | 0.06      | .0005            | 1.89                           | 259,000   |
| March, .     | -                                                                   | -                       | -         | -                                                                              | -           | -      | -        | -           | -           | -         | -                | -                              | -         |
| April, .     | 332,000                                                             | 51                      | 48        | 10                                                                             | Great.      | 0.45   | 0.6000   | .2250       | 8.91        | 2.41      | .0260            | 1.08                           | 226,000   |
| May, .       | 267,000                                                             | 62                      | 54        | 4                                                                              | Decided.    | 0.45   | 1.9500   | .1800       | 11.87       | 1.57      | .0110            | 1.50                           | 188,000   |
| June, .      | 499,000                                                             | 72                      | 69        | 11                                                                             | Slight.     | 0.30   | 0.0186   | .0514       | 13.87       | 3.13      | .0018            | 0.38                           | 59,000    |
| July, .      | 427,000                                                             | 71                      | 70        | 4                                                                              | Slight.     | 0.20   | 0.0305   | .0327       | 15.36       | 4.04      | .0015            | 0.29                           | 87,000    |
| August, .    | 219,000                                                             | 73                      | 75        | 9                                                                              | Decided.    | -      | 1.2150   | .1350       | 16.29       | 0.19      | .0215            | 1.02                           | 399,000   |
| September, . | 360,000                                                             | 69                      | 67        | 12                                                                             | Slight.     | 0.23   | 0.2500   | .0524       | 16.17       | 3.52      | .0057            | 0.35                           | 111,000   |
| October, .   | 360,000                                                             | 56                      | 55        | 12                                                                             | Slight.     | 0.31   | 0.6700   | .1067       | 11.07       | 3.07      | .0304            | 0.70                           | 203,000   |
| November, .  | 360,000                                                             | 54                      | 51        | 12                                                                             | Decided.    | 0.34   | 0.6433   | .1020       | 10.05       | 3.02      | .1253            | 0.89                           | 282,000   |
| December, .  | 360,000                                                             | 45                      | 47        | 12                                                                             | Decided.    | 0.33   | 0.3967   | .1140       | 10.03       | 3.38      | .0100            | 0.76                           | 307,000   |

Sewage applied, 2 gallons twelve times a day at intervals of one-half hour, six days in a week, January 1 to August 20;  $1\frac{1}{2}$  gallons twelve times a day from August 21 to December 31. No sewage applied and aspiration continuous, January 5 to 10, January 28 to February 3, February 18 to March 31, May 18 to 31, August 7 to 20. April 10 to 21, experiment interrupted by freshet. Filter aspirated sixteen hours each night. Surface raked 3 inches deep daily January 1 to March 31, and once a week during the remainder of the year. April 1, filter filled to its original depth with washed gravel. April 20, 6 inches of gravel removed, washed and replaced in tank. January 30, surface dug over 12 inches deep. Surface scraped on January 4 and April 1.

*Filter No. 22 A.*

This filter contained originally 60 inches of fine coke breeze above the usual under-drains. The rate of filtration during 1895 has been 360,000 gallons per acre daily. On account of clogging during February the filter was allowed to rest from February 18 to April 1. The surface of the filter was raked to a depth of 3 inches daily until the period of rest and to the same depth twice each week during the remainder of the year. Up to Nov. 14, 1894, 3.5 inches of the surface coke had been removed, equivalent to 8.6 cubic yards per 1,000,000 gallons of sewage filtered. During 1895 6.1 inches of coke were removed up to November 14, equivalent to 15 cubic yards per 1,000,000 gallons of sewage filtered. With the exception of the months of January and February nitrification in the filter was active throughout the year. The table of monthly averages of the weekly analyses is presented below: —

*Monthly Averages of Analyses of Effluent of Filter No. 22 A.*

[Parts per 100,000.]

| 1895.       | Quantity Applied.<br>Gallons per Acre<br>Daily for Six<br>Days in a<br>Week. | TEMPERATURE.<br>DEG. F. |           | Length of Time<br>Sewage<br>Remained<br>on<br>Surface.<br>Minutes. | APPEARANCE. |        | AMMONIA. |             | NITROGEN<br>AS |          | Oxygen Consumed. | Bacteria per Cubic<br>Centimeter. |          |
|-------------|------------------------------------------------------------------------------|-------------------------|-----------|--------------------------------------------------------------------|-------------|--------|----------|-------------|----------------|----------|------------------|-----------------------------------|----------|
|             |                                                                              | Sewage.                 | Effluent. |                                                                    | Turbidity.  | Color. | Free.    | Albuminoid. | Chlorine.      | Nitrate. |                  |                                   | Nitrite. |
| January, .  | 360,000                                                                      | 47                      | 40        | 29m.                                                               | Decided.    | .32    | 2.2140   | .1205       | 8.31           | 0.57     | .0067            | .72                               | 254,000  |
| February, . | 215,000                                                                      | 46                      | 37        | 22m.                                                               | Decided.    | .57    | 3.0250   | .1350       | 7.74           | 0.18     | .0057            | .57                               | 153,000  |
| March, .    | -                                                                            | -                       | -         | -                                                                  | -           | -      | -        | -           | -              | -        | -                | -                                 | -        |
| April, .    | 245,000                                                                      | 51                      | 48        | 7m.                                                                | Decided.    | .33    | 1.3250   | .1650       | 9.56           | 1.97     | .0590            | .68                               | 132,000  |
| May, . .    | 360,000                                                                      | 62                      | 57        | 25m.                                                               | Slight.     | .30    | 1.2080   | .0760       | 12.68          | 1.16     | .0124            | .44                               | 94,000   |
| June, . .   | 374,000                                                                      | 72                      | 69        | 12m.                                                               | Decided.    | .35    | 0.7900   | .0730       | 14.72          | 1.55     | .0110            | .50                               | 338,000  |
| July, . .   | 347,000                                                                      | 71                      | 68        | 29m.                                                               | Decided.    | .31    | 0.3700   | .0590       | 18.09          | 2.10     | .0084            | .47                               | 78,000   |
| August, .   | 360,000                                                                      | 73                      | 71        | 14m.                                                               | Decided.    | .26    | 0.1582   | .0412       | 13.93          | 2.30     | .0060            | .32                               | 92,000   |
| September,  | 360,000                                                                      | 69                      | 66        | 23m.                                                               | Decided.    | .23    | 0.1233   | .0527       | 14.44          | 2.34     | .0150            | .33                               | 86,000   |
| October, .  | 360,000                                                                      | 56                      | 53        | 13m.                                                               | Slight.     | .33    | 0.7633   | .0637       | 11.28          | 1.63     | .0087            | .41                               | 102,000  |
| November,   | 360,000                                                                      | 54                      | 47        | 50m.                                                               | Decided.    | .35    | 0.9575   | .0730       | 8.51           | 1.35     | .0450            | .52                               | 128,000  |
| December,   | 360,000                                                                      | 45                      | 46        | 23m.                                                               | Decided.    | .54    | 1.4300   | .1640       | 9.93           | 0.94     | .0267            | .60                               | 479,000  |

Sewage applied, 6 gallons eighteen times a week. No sewage applied February 18 to March 31. April 10 to 21, experiment interrupted by freshet. Surface raked 3 inches deep daily, January 1 to 31, and once a week during the remainder of the year. February 1, 3 inches of coke removed, and 3 inches of clean coke put on filter. February 18,  $\frac{1}{2}$  inch of coke removed from filter; November 15, 3.1 inches removed.

*. Filters Nos. 51 and 52.*

Each of these filters is one three-thousandth of an acre in area. Filter No. 51 contains 60 inches in depth of gravel of an effective size of 5.30 millimeters above the usual under-drains, and Filter No. 52 contains 60 inches in depth of coke breeze, from which the finer particles have been removed, above the usual under-drains. The outlets of these two filters have been trapped and they have been aerated by means of a fan blower driven by electric power, as previously described. Beginning February 1, each of these filters received sewage at the rate of 500,000 gallons per acre daily, applied in six doses between 6 A.M. and noon. This rate of filtration and method of application continued until May 2, when the method of application was changed so that twice this volume of sewage was applied in twelve doses between 7 A.M. and 11 P.M., giving a rate of 1,000,000 gallons per acre daily. This continued until June 21. From June 21 to June 25 inclusive the filters were allowed to rest, and on June 26 they were started again, but the rate of application of sewage was reduced to 500,000 gallons per acre daily, applied in six doses between 7 A.M. and 10 P.M. This continued until June 29, when the same quantity of sewage was applied in twelve doses between 7 A.M. and 11.30 P.M. During these first five months of operation of the filters nitrification did not become well established, and although there was a considerable reduction of the free and albuminoid ammonia of the sewage in passing through the filters, it was largely on account of retention and storage in the filters. From July 2 to 7 inclusive, the rate of application was 250,000 gallons per acre daily, and from July 8 to 17 inclusive, the filters were operating very poorly, the method of application was irregular and the average rate was less than 100,000 gallons per acre daily. This low rate improved the condition of the filters and nitrification became established.

From July 18 to August 13 the rate of filtration was 250,000 gallons per acre daily and was applied in three doses between 7 A.M. and 2.30 P.M. From August 14 to September 2 inclusive, the rate of filtration was 500,000 gallons per acre daily, applied in six equal doses between 7 A.M. and 10 P.M., and from September 2 until the end of the experiment, December 10, the rate was 1,000,000 gallons per acre daily, applied in twelve equal doses between 7 A.M. and 11.30 P.M. During the last five months of operation of the filters

nitrification was active within the filters, but the effluents, especially that of Filter No. 51, contained a large amount of free and albuminoid ammonia. The better clarification of the effluent of Filter No. 52 was on account of greater storage of organic matter within the filter.

From February 12 to May 2 the filters were aerated two hours daily, from 2 to 4 P.M. From May 2 to June 1, one and one-half hours daily, divided into half-hour periods, June 1 to 15, six half hours daily, June 16 to July 10, twelve half hours daily, July 15 to August 5, fourteen hours daily. August 6 to 11 the motor was out of order and the average period of aëration was one and one-half hours daily, with no aëration on August 7, 9 and 10. From August 13 to September 3 the filters were aerated fourteen hours daily, and from September 3 until the end of the experiment, with a few exceptions, the filters were aerated two and three-fourths hours daily, in fifteen minute periods, half way between the times of applying the sewage.

*Monthly Averages of Analyses of Effluent of Filter No. 51.*

[Parts per 100,000.]

| 1895.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE,<br>DEG. F. |           | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS |          | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|-------------|--------|----------|-------------|-----------|-------------|----------|------------------|--------------------------------|
|              |                                                                     | Sewage.                 | Effluent. | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrate.    | Nitrite. |                  |                                |
| February, .  | 500,000                                                             | 46                      | 47        | Decided.    | 1.30   | 2.5167   | .3767       | 13.13     | 0.00        | .0000    | 2.30             | 781,500                        |
| March, .     | 500,000                                                             | 47                      | 51        | Great.      | 1.23   | 2.2400   | .3360       | 7.51      | 0.22        | .0340    | 2.32             | 226,000                        |
| April, .     | 500,000                                                             | 51                      | 52        | Decided.    | 0.93   | 1.8333   | .3367       | 8.69      | 0.64        | .1547    | 2.30             | 581,000                        |
| May, .       | 1,000,000                                                           | 60                      | 60        | Great.      | 0.57   | 1.8900   | .2960       | 11.89     | 0.45        | .0162    | 1.47             | 630,000                        |
| June, .      | 675,000                                                             | 72                      | 72        | Great.      | -      | 2.8625   | .3275       | 11.03     | 0.02        | .0000    | 1.95             | 423,000                        |
| July, .      | 165,000                                                             | 71                      | 71        | Great.      | red    | 3.8833   | .3867       | 18.26     | 0.80        | .0437    | 2.15             | 725,000                        |
| August, .    | 500,000                                                             | 73                      | 72        | Great.      | -      | 1.9700   | .4364       | 17.29     | 2.19        | .1670    | 2.75             | 685,000                        |
| September, . | 1,000,000                                                           | 69                      | 69        | Great.      | -      | 1.6500   | .5075       | 12.62     | 1.48        | .1613    | 2.83             | 874,000                        |
| October, .   | 1,000,000                                                           | 56                      | 56        | Great.      | -      | 1.7900   | .3936       | 9.89      | 1.32        | .3260    | 2.98             | 785,000                        |
| November, .  | 1,000,000                                                           | 54                      | 54        | Great.      | 0.70   | 1.1300   | .3100       | 8.75      | 1.33        | .4500    | 3.25             | 489,000                        |
| December, .  | 1,000,000                                                           | 45                      | 52        | Great.      | 0.80   | 0.7250   | .4600       | 5.44      | 1.85        | .1750    | 2.80             | 529,000                        |

Sewage applied, 25 gallons thirty-six times a week, February 1 to April 30; 25 gallons seventy-two times a week, May 1 to June 25; 25 gallons thirty-six times a week, June 26 to 28; 12½ gallons seventy-two times a week, June 29 to July 1; 12½ gallons thirty-six times a week, July 2 to 7; 6½ gallons thirty-six times a week, July 8 to 17; 25 gallons eighteen times a week, July 18 to August 13; 25 gallons thirty-six times a week, August 14 to September 1; 25 gallons seventy-two times a week, September 2 to December 10. Blower ran 2 hours six times a week, February 18 to April 30; ¼ hour eighteen times a week, May 1 to June 3; ½ hour thirty-six times a week, June 4 to 14; ½ hour seventy-two times a week, June 15 to July 9; 1½ hours daily, six days a week, July 10 to September 1; 15 minutes sixty-six times a week, September 2 to December 10. February 4, a trap 2 feet high was attached to outlet. March 2, 5 inches of gravel removed from filters 15 and 16, and the whole quantity thoroughly mixed with the top foot of gravel in Filter No. 51. April 15 to 21, experiment interrupted by freshet. Trap washed out once a week after July 22. Surface raked 3 inches deep once a week, April 1 to September 2. Surface dug over 6 inches deep July 10 and November 30.

*Monthly Averages of Analyses of Effluent of Filter No. 52.*

[Parts per 100,000.]

| 1895.        | Quantity Applied.<br>Gallons per Acre<br>Daily for Six<br>Days in a<br>Week. | TEMPERATURE.<br>DEG. F. |           | APPEARANCE. |        | AMMONIA. |             |           | NITROGEN<br>AS |          | Oxygen Consumed. | Bacteria per Cubic<br>Centimeter. |
|--------------|------------------------------------------------------------------------------|-------------------------|-----------|-------------|--------|----------|-------------|-----------|----------------|----------|------------------|-----------------------------------|
|              |                                                                              | Sewage.                 | Effluent. | Turbidity.  | Color. | Free.    | Albuminoid. | Chlorine. | Nitrate.       | Nitrite. |                  |                                   |
| February, .  | 500,000                                                                      | 46                      | 46        | Decided.    | 1.27   | 3.1667   | .2933       | 11.95     | 0.00           | .0001    | 1.93             | 1,163,000                         |
| March, .     | 500,000                                                                      | 47                      | 50        | Great.      | 1.27   | 2.7300   | .3160       | 7.25      | 0.15           | .0470    | 2.18             | 238,000                           |
| April, .     | 500,000                                                                      | 51                      | 52        | Great.      | 0.70   | 2.1333   | .3033       | 8.66      | 0.43           | .0997    | 2.00             | 433,000                           |
| May, .       | 1,000,000                                                                    | 62                      | 60        | Great.      | 0.66   | 1.4500   | .2040       | 11.69     | 0.47           | .0159    | 1.19             | 648,000                           |
| June, .      | 675,000                                                                      | 72                      | 72        | Great.      | 0.90   | 2.1375   | .2825       | 11.64     | 0.07           | .0000    | 1.52             | 405,000                           |
| July, .      | 165,000                                                                      | 71                      | 71        | Great.      | red    | 2.3333   | .1833       | 17.32     | 0.02           | .0000    | 1.25             | 118,000                           |
| August, .    | 500,000                                                                      | 73                      | 72        | Great.      | —*     | 1.2700   | .1776       | 17.21     | 1.61           | .0846    | 1.20             | 433,000                           |
| September, . | 1,000,000                                                                    | 69                      | 69        | None.       | red    | 1.7250   | .2550       | 15.83     | 0.69           | .0647    | 1.80             | 195,000                           |
| October, .   | 1,000,000                                                                    | 56                      | 56        | None.       | 0.57   | 2.4700   | .3060       | 11.52     | 0.43           | .1741    | 1.94             | 408,000                           |
| November, .  | 1,000,000                                                                    | 54                      | 54        | None.       | 0.75   | 1.4000   | .2850       | 8.45      | 1.05           | .0250    | 1.00             | 398,000                           |
| December, .  | 1,000,000                                                                    | 45                      | 51        | Great.      | 0.58   | 1.2250   | .2450       | 6.56      | 0.48           | .1400    | 1.25             | 343,000                           |

\* Brown.

Sewage applied, 25 gallons thirty-six times a week, February 1 to April 30; 25 gallons seventy-two times a week, May 1 to June 25; 25 gallons thirty-six times a week, June 26 to 28; 12½ gallons seventy-two times a week, June 29 to July 1; 12½ gallons thirty-six times a week, July 2 to 7; 6½ gallons thirty-six times a week, July 8 to 17; 25 gallons eighteen times a week, July 18 to August 13; 25 gallons thirty-six times a week, August 14 to September 1; 25 gallons seventy-two times a week, September 2 to December 10. Blower ran 2 hours six times a week, February 18 to April 30; ½ hour eighteen times a week, May 1 to June 3; ½ hour thirty-six times a week, June 4 to 14; ½ hour seventy-two times a week, June 15 to July 9; 13½ hours daily six days a week, July 10 to September 1; 15 minutes sixty-six times a week, September 2 to December 10. February 4, a trap 2 feet high was attached to outlet. April 15 to 21, experiment interrupted by freshet. Trap washed out once a week after July 22. August 1 to 4, all the air from the blower passing through tank. Surface raked 3 inches deep once a week, April 1 to September 2. Surface dug over 6 inches deep July 10, November 30, and 12 inches deep July 26.

*Filter No. 53.*

This filter is one twenty-thousandth of an acre in area, and contains 60 inches in depth of sand of an effective size of 0.19 millimeter. From February 1 to May 17 it received the effluent of No. 51 at the rate of 1,000,000 gallons per acre daily. Following this treatment the surface of the filter became so badly clogged by the excessive application of partially purified sewage that the rate had to be greatly reduced and was quite irregular in volume, the average rate from May 17 to July 19 averaging considerably less than 500,000 gallons per acre daily. From this last date until the end of the experiment, December 10, the average rate was 500,000 gallons per

acre daily. During this last period the applied effluent of Filter No. 51 was fairly well purified and contained nitrates in considerable quantity. The filter was allowed to rest from June 21 to 25 inclusive and July 11 to 15 inclusive. The surface was raked 3 inches deep twice each week during April, and beginning May 2, to the same depth daily. The surface was spaded over to a depth of 6 inches May 22, June 3, 13, 20 and November 22. The following table shows the results of the monthly averages of the analyses of the effluent of this filter:—

*Monthly Averages of Analyses of Effluent of Filter No. 53.*

[Parts per 100,000.]

| 1895.        | Quantity Applied<br>Gallons per Acre<br>Daily for Six<br>Days in a<br>Week. | TEMPERATURE.<br>DEG. F. |           | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Bacteria per Cubic<br>Centimeter. |
|--------------|-----------------------------------------------------------------------------|-------------------------|-----------|-------------|--------|----------|-------------|-----------|----------------|-----------|------------------|-----------------------------------|
|              |                                                                             | Sewage.                 | Effluent. | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrates.      | Nitrites. |                  |                                   |
| February, .  | 1,003,000                                                                   | 46                      | 50        | Slight.     | .36    | 3.0833   | .1767       | 12.77     | 0.06           | .0007     | .77              | 1,041,000                         |
| March, .     | 1,006,000                                                                   | 47                      | 54        | Slight.     | .41    | 1.7414   | .1352       | 7.65      | 1.68           | .0854     | .74              | 62,000                            |
| April, .     | 789,000                                                                     | 51                      | 49        | V. slight.  | .31    | 0.0127   | .0467       | 8.83      | 1.93           | .0037     | .48              | 46,000                            |
| May, .       | 973,000                                                                     | 62                      | 58        | V. slight.  | .28    | 0.2476   | .0576       | 11.16     | 1.09           | .0020     | .55              | 416,000                           |
| June, .      | 867,000                                                                     | 72                      | 69        | Decided.    | .56    | 0.6225   | .1080       | 12.00     | 0.45           | .0345     | .88              | 95,000                            |
| July, .      | 353,000                                                                     | 72                      | 69        | V. slight.  | .30    | 0.3482   | .0766       | 16.17     | 2.73           | .0066     | .27              | 28,000                            |
| August, .    | 500,000                                                                     | 75                      | 70        | V. slight.  | .21    | 0.0391   | .0356       | 17.36     | 2.71           | .0008     | .30              | 6,000                             |
| September, . | 500,000                                                                     | 69                      | 67        | V. slight.  | .20    | 0.0181   | .0304       | 19.36     | 2.23           | .0023     | .33              | 4,000                             |
| October, .   | 500,000                                                                     | 55                      | 51        | None.       | .16    | 0.0578   | .0252       | 13.72     | 3.98           | .0018     | .27              | 10,000                            |
| November, .  | 498,000                                                                     | 57                      | 54        | V. slight.  | .27    | 0.0959   | .0390       | 9.09      | 3.15           | .0007     | .34              | 14,000                            |
| December, .  | 500,000                                                                     | 53                      | 58        | V. slight.  | .19    | 0.0132   | .0291       | 8.81      | 3.03           | .0002     | .25              | 8,000                             |

Effluent of Filter No. 51 applied, 16½ gallons eighteen times a week, February 1 to May 1; 12½ gallons twenty-four times a week, May 2 to July 1; from July 2 to 22, amount of applied effluent varied from 2 gallons to 32½ gallons daily; 12½ gallons twelve times a week, July 23 to December 10. February 18, ½ inch of sand removed from surface of Filter No. 12 and thoroughly mixed with top foot of sand in Filter No. 53. April 15 to 21, experiment interrupted by freshet. Surface raked 3 inches deep once a week, April 1 to 22, and daily from April 23 to December 10. Surface dug over 6 inches deep, May 22, June 3, 13, 20, November 22.

#### *Filter No. 54.*

This filter is a duplicate of Filter No. 53, and has received during its period of operation the effluent of Filter No. 52. The effluent was applied at an average rate of 1,000,000 gallons per acre daily until the middle of June, when the surface of the filter became badly clogged. On June 13 the surface was spaded over to a depth of 6 inches and the filter was allowed to rest from June 21 to 25 in-

clusive. The condition of the filter did not improve and the average rate of application of the partially purified sewage was, during July, 356,000 gallons per acre daily. During the remaining period of operation of this filter the applied effluent contained nitrogen, in the form of nitrates, in considerable quantities, and was of such quality that the filter disposed of it at an average rate of 500,000 gallons per acre daily, without difficulty. The surface of the filter was raked to a depth of 3 inches once each week from April 1 until April 23, and after this date to the same depth daily. The surface was spaded over to a depth of 6 inches May 25, June 13, 29 and November 6. The quality of the effluent during the period of operation of the filter is shown by the following table:—

*Monthly Averages of Analyses of Effluent of Filter No. 54.*

[Parts per 100,000.]

| 1895.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|-------------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|              |                                                                     | Sewage.                 | Effluent. | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |
| February, .  | 976,000                                                             | 47                      | 46        | Slight.     | .35    | 3.2500   | .1533       | 11.53     | 0.01        | .0015     | .64              | 1,297,000                      |
| March, .     | 1,011,000                                                           | 50                      | 51        | Slight.     | .38    | 2.8600   | .1220       | 7.64      | 0.51        | .0170     | .65              | 35,000                         |
| April, . .   | 788,000                                                             | 51                      | 49        | V. slight.  | .28    | 0.3687   | .0480       | 8.66      | 1.74        | .0083     | .44              | 10,000                         |
| May, . . .   | 977,000                                                             | 62                      | 58        | V. slight.  | .23    | 0.0338   | .0360       | 11.33     | 1.54        | .0044     | .39              | 10,000                         |
| June, . . .  | 792,000                                                             | 71                      | 68        | V. slight.  | .29    | 0.0582   | .0430       | 12.45     | 1.55        | .0050     | .41              | 9,000                          |
| July, . . .  | 356,000                                                             | 72                      | 69        | V. slight.  | .21    | 0.0081   | .0402       | 17.43     | 3.06        | .0007     | .31              | 5,000                          |
| August, . .  | 500,000                                                             | 75                      | 69        | V. slight.  | .15    | 0.0044   | .0259       | 16.49     | 2.44        | .0003     | .23              | 14,000                         |
| September, . | 500,000                                                             | 69                      | 67        | V. slight.  | .18    | 0.0145   | .0278       | 17.38     | 2.19        | .0001     | .26              | 13,000                         |
| October, . . | 500,000                                                             | 55                      | 52        | None.       | .17    | 0.0174   | .0259       | 13.00     | 2.58        | .0001     | .26              | 3,000                          |
| November, .  | 475,000                                                             | 57                      | 48        | None.       | .38    | 0.8164   | .0503       | 9.65      | 1.31        | .0072     | .48              | 2,600                          |
| December, .  | 468,000                                                             | 53                      | 55        | None.       | .16    | 0.0102   | .0248       | 8.54      | 1.94        | .0011     | .24              | 500                            |

Effluent of Filter No. 52 applied, 16½ gallons eighteen times a week, February 1 to May 1; 12½ gallons twenty-four times a week, May 2 to June 29; from June 30 to July 21, amount of applied effluent varied from 3 gallons to 47½ gallons daily; 12½ gallons twelve times a week, July 22 to December 10. April 16 to 21, experiment interrupted by freshet. Surface raked 3 inches deep once a week, April 1 to 22, and daily from April 23 to December 10. Surface dug over 6 inches deep, May 25, June 13, 29, November 24, December 5.

### *Filter No. 55.*

This filter is one twenty-thousandth of an acre in area, and contains, over the usual gravel under-drains, 5 feet in depth of sand of an effective size of 0.40 millimeter. To this filter the effluent of



Filter No. 51 was applied. The average rate of application during the first five months of operation of the filter was, excluding periods of rest, 1,000,000 gallons per acre daily. The surface of the filter became very badly clogged by this excessive application of partially purified sewage and the filter was allowed to rest from July 3 to 15 inclusive. During the remainder of the year the rate of application was 500,000 gallons per acre daily. The surface of the filter was not disturbed until April; during April it was raked 3 inches deep each week until April 23, and from this last date, until the end of the experiment, to the same depth daily. The surface of the filter was dug over to a depth of 6 inches April 13, May 24, June 7 and 18. The quality of the effluent of the filter is shown by the following table:—

*Monthly Averages of Analyses of Effluent of Filter No. 55.*

[Parts per 100,000.]

| 1895.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | APPEARANCE. |        | AMMONIA. |             | NITROGEN AS |           |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|-------------|--------|----------|-------------|-------------|-----------|-----------|------------------|--------------------------------|
|              |                                                                     | Sewage.                 | Effluent. | Turbidity.  | Color. | Free.    | Albuminoid. | Chlorine.   | Nitrates. | Nitrites. |                  |                                |
| February, .  | 1,003,000                                                           | 47                      | 48        | Decided.    | .48    | 2.7667   | .2233       | 13.09       | 0.007     | .0005     | 1.01             | 3,524,000                      |
| March, .     | 1,006,000                                                           | 50                      | 53        | Decided.    | .55    | 2.4700   | .1340       | 7.94        | 0.700     | .0370     | 0.95             | 68,000                         |
| April, .     | 750,000                                                             | 51                      | 50        | Slight.     | .44    | 0.4460   | .0753       | 8.71        | 2.070     | .0500     | 0.67             | 84,000                         |
| May, .       | 974,000                                                             | 62                      | 59        | Slight.     | .37    | 0.2988   | .0746       | 10.98       | 1.300     | .0136     | 0.66             | 110,000                        |
| June, .      | 851,000                                                             | 71                      | 70        | Great.      | .76    | 1.1625   | .1405       | 11.96       | 0.320     | .0320     | 1.20             | 126,000                        |
| July, .      | 280,000                                                             | 72                      | 69        | Decided.    | .60    | 1.2707   | .1220       | 16.85       | 1.180     | .0347     | 0.81             | 337,000                        |
| August, .    | 500,000                                                             | 75                      | 71        | Decided.    | .34    | 0.0668   | .0632       | 17.35       | 3.020     | .0112     | 0.44             | 269,000                        |
| September, . | 500,000                                                             | 69                      | 68        | Decided.    | .31    | 0.0367   | .0500       | 18.81       | 2.930     | .0020     | 0.46             | 166,000                        |
| October, .   | 500,000                                                             | 55                      | 53        | Decided.    | .30    | 0.0633   | .0520       | 15.39       | 4.210     | .0206     | 0.42             | 71,000                         |
| November, .  | 500,000                                                             | 57                      | 51        | Slight.     | .37    | 0.0570   | .0670       | 9.03        | 3.510     | .0130     | 0.47             | 73,000                         |
| December, .  | 500,000                                                             | 53                      | 55        | Slight.     | .35    | 0.0440   | .0580       | 8.41        | 3.230     | .0070     | 0.43             | 48,000                         |

Effluent of Filter No. 51 applied, 10½ gallons eighteen times a week, February 1 to May 1; 12½ gallons twenty-four times a week, May 2 to July 1; none applied July 2 to 15; from July 16 to 22, amount of applied effluent varied from 3 gallons to 25 gallons daily; 12½ gallons twelve times a week, July 23 to December 10. February 18, ½ inch of sand removed from surface of Filter No. 1 and thoroughly mixed with top foot of sand in Filter No. 55. April 15 to 21, experiment interrupted by freshet. May 24, a ½-inch pipe, similar to the ones in filters 15 and 16, was driven down through the center of the filter, and an aspirator attached. Surface raked 3 inches deep once a week, April 1 to 22, and daily from April 23 to December 10. Surface dug over 6 inches deep April 13, May 24, June 7, 18.

*Filter No. 56.*

This filter is in area and construction a duplicate of Filter No. 55, and has had applied to it, during its period of operation, the effluent of Filter No. 52. The rate of application of this effluent was, during the first five months of operation of the filter, approximately 1,000,000 gallons per acre daily. The surface of the filter became quite badly clogged during July and the rate of application was very much reduced, averaging for the month 356,000 gallons per acre daily. From the beginning of August until the end of the experiment the quality of the effluent of Filter No. 52 was much improved, and was disposed of readily by Filter No. 56 at an average rate of 500,000 gallons per acre daily. The surface of the filter was not disturbed until April. During the first three weeks of April it was raked to a depth of 3 inches three times, and beginning April 23, to the same depth daily.

*Monthly Averages of Analyses of Effluent of Filter No. 56.*

[Parts per 100,000.]

| 1895.        | Quantity Applied.<br>Gallons per Acre.<br>Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|-------------------------------------------------------------------------|-------------------------|-----------|-------------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|              |                                                                         | Sewage.                 | Effluent. | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |
| February, .  | 974,000                                                                 | 47                      | 47        | Decided.    | .36    | 3.2833   | .1666       | 11.87     | 0.00        | .0005     | .73              | 3,621,000                      |
| March, .     | 1,011,000                                                               | 50                      | 52        | Slight.     | .43    | 2.4700   | .1160       | 7.72      | 0.60        | .0238     | .77              | 48,000                         |
| April, .     | 788,000                                                                 | 51                      | 50        | V. slight.  | .38    | 0.1953   | .0533       | 8.58      | 2.83        | .0183     | .47              | 21,000                         |
| May, .       | 963,000                                                                 | 62                      | 58        | Slight.     | .28    | 0.0613   | .0641       | 11.15     | 2.46        | .0172     | .46              | 101,000                        |
| June, .      | 878,000                                                                 | 71                      | 69        | Slight.     | .33    | 0.1003   | .0695       | 12.16     | 1.91        | .0480     | .48              | 55,000                         |
| July, .      | 336,000                                                                 | 72                      | 69        | Slight.     | .29    | 0.2400   | .0553       | 16.82     | 2.15        | .0273     | .40              | 395,000                        |
| August, .    | 500,000                                                                 | 75                      | 70        | V. slight.  | .17    | 0.0076   | .0360       | 16.41     | 2.73        | .0083     | .24              | 24,000                         |
| September, . | 500,000                                                                 | 69                      | 68        | V. slight.  | .20    | 0.0344   | .0335       | 17.55     | 2.06        | .0018     | .30              | 41,000                         |
| October, .   | 500,000                                                                 | 55                      | 53        | None.       | .18    | 0.0281   | .0266       | 13.19     | 2.33        | .0040     | .27              | 11,000                         |
| November, .  | 477,000                                                                 | 57                      | 53        | Slight.     | .53    | 2.1800   | .0950       | 9.18      | 0.84        | .0560     | .73              | 30,000                         |
| December, .  | 500,000                                                                 | 53                      | 54        | Slight.     | .21    | 0.0082   | .0285       | 8.63      | 2.00        | .0065     | .27              | 20,000                         |

Effluent of Filter No. 52 applied, 16½ gallons eighteen times a week, February 1 to May 1; 12½ gallons twenty-four times a week, May 2 to June 28; from June 29 to July 21, the amount of applied effluent varied from 3 gallons to 47½ gallons daily; 12½ gallons twelve times a week, July 22 to December 10. April 15 to 21, experiment interrupted by freshet. Surface raked 3 inches deep once each week, April 1 to 22, and daily from April 23 to December 10. Surface dug over 6 inches deep, November 23.

*Filter No. 57.*

This filter is one twenty-thousandth of an acre in area, and contains, over the usual under-drains, 5 feet in depth of coke breeze. The effluent of Filter No. 51 has been applied to this filter. During the first five months of its period of operation the rate of application was, approximately, 1,000,000 gallons per acre daily. This rate of application overtaxed the capacity of the filter and its surface became so badly clogged that during July the rate of application was very much reduced and was quite irregular. From the first of August through the remaining months of operation of the filter it disposed of the better purified effluent of Filter No. 51 without difficulty at an average rate of 500,000 gallons per acre daily. The surface of the filter was not disturbed until April. During April the surface was raked to a depth of 3 inches three times up to April 23 and from that date daily throughout the remaining months of the experiment.

*Monthly Averages of Analyses of Effluent of Filter No. 57.*

(Parts per 100,000.)

| 1895.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|-------------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|              |                                                                     | Sewage.                 | Effluent. | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrates.   | Nitriles. |                  |                                |
| February, .  | 1,003,000                                                           | 47                      | 48        | Decided.    | .35    | 2.8833   | .1467       | 11.67     | 0.00        | .0007     | .73              | 490,000                        |
| March, .     | 1,006,000                                                           | 50                      | 53        | Slight.     | .57    | 2.2700   | .1840       | 8.08      | 0.56        | .0267     | .87              | 68,000                         |
| April, .     | 788,000                                                             | 51                      | 51        | Slight.     | .55    | 0.4433   | .0767       | 8.44      | 1.74        | .0133     | .64              | 79,000                         |
| May, .       | 1,014,000                                                           | 62                      | 59        | Decided.    | .32    | 0.2120   | .0636       | 10.82     | 1.49        | .0132     | .51              | 128,000                        |
| June, .      | 875,000                                                             | 71                      | 70        | Slight.     | .31    | 0.6550   | .0650       | 12.05     | 1.16        | .0205     | .41              | 44,000                         |
| July, .      | 353,000                                                             | 72                      | 69        | Slight.     | .42    | 1.3567   | .0660       | 16.27     | 0.85        | .0133     | .44              | 154,000                        |
| August, .    | 500,000                                                             | 75                      | 71        | Slight.     | .28    | 0.1860   | .0400       | 17.01     | 2.34        | .0186     | .33              | 214,000                        |
| September, . | 500,000                                                             | 69                      | 68        | Decided.    | .29    | 0.1053   | .0487       | 17.89     | 2.38        | .0067     | .36              | 107,000                        |
| October, .   | 500,000                                                             | 55                      | 54        | Slight.     | .22    | 0.0627   | .0373       | 14.17     | 3.16        | .0093     | .32              | 68,000                         |
| November, .  | 500,000                                                             | 57                      | 53        | Slight.     | .33    | 0.1920   | .0400       | 9.48      | 2.77        | .0240     | .35              | 22,000                         |
| December, .  | 500,000                                                             | 53                      | 55        | Slight.     | .31    | 0.3730   | .0460       | 9.01      | 2.63        | .0200     | .87              | 18,000                         |

Effluent of Filter No. 51 applied, 16½ gallons eighteen times a week, February 1 to May 1; 12½ gallons twenty-four times a week, May 2 to June 23; from June 29 to July 22, the amount of applied effluent varied from 2 gallons to 47½ gallons daily; 12½ gallons twelve times a week, July 23 to December 10. April 15 to 21, experiment interrupted by freshet. Surface raked 3 inches deep once each week, April 1 to 22, and daily from April 23 to December 10.

*Filter No. 58.*

This filter is, in area and construction, a duplicate of Filter No. 57, and has had applied to it during its period of operation the effluent of Filter No. 52. During the first five months of its period of operation the rate of application was, approximately, 1,000,000 gallons per acre daily. This overtaxed the capacity of the filter and during July the rate was much less and quite irregular. From August 1 throughout the remaining months of operation of the filter the average rate of application was 500,000 gallons per acre daily, and the filter disposed of it without difficulty. The surface of the filter was not disturbed until April. During April it was raked to the depth of 3 inches once each week to April 23, and from this date until the end of the experiment to the same depth daily.

*Monthly Averages of Analyses of Effluent of Filter No. 58.*

[Parts per 100,000.]

| 1895.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|-------------|--------|----------|-------------|-----------|-------------|-----------|------------------|-------------------------------|
|              |                                                                     | Sewage.                 | Effluent. | Turbidity.  | Color. | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                               |
| February, .  | 975,000                                                             | 47                      | 44        | Decided.    | .32    | 3.4000   | .1438       | 11.08     | 0.01        | .0040     | .64              | 316,000                       |
| March, . .   | 1,011,000                                                           | 50                      | 52        | Slight.     | .36    | 2.0700   | .1108       | 7.88      | 0.65        | .0202     | .58              | 43,000                        |
| April, . .   | 788,000                                                             | 51                      | 51        | Decided.    | .46    | 0.3400   | .0613       | 8.59      | 1.73        | .0090     | .48              | 59,000                        |
| May, . . .   | 1,014,000                                                           | 62                      | 58        | Slight.     | .25    | 0.2080   | .0496       | 11.44     | 1.77        | .0130     | .39              | 115,000                       |
| June, . . .  | 876,000                                                             | 71                      | 70        | Slight.     | .30    | 0.2555   | .0490       | 12.82     | 1.66        | .0180     | .33              | 50,000                        |
| July, . . .  | 355,000                                                             | 72                      | 69        | Slight.     | .30    | 0.1081   | .0523       | 16.31     | 1.83        | .0087     | .28              | 214,000                       |
| August, . .  | 500,000                                                             | 75                      | 70        | Slight.     | .25    | 0.0520   | .0265       | 16.40     | 2.33        | .0052     | .21              | 86,000                        |
| September, . | 500,000                                                             | 69                      | 68        | Slight.     | .21    | 0.0273   | .0319       | 16.43     | 2.26        | .0017     | .20              | 67,000                        |
| October, . . | 500,000                                                             | 55                      | 56        | Slight.     | .24    | 0.0526   | .0300       | 12.02     | 2.25        | .0047     | .22              | 35,000                        |
| November, .  | 500,000                                                             | 57                      | 54        | Slight.     | .29    | 0.0590   | .0390       | 9.27      | 2.26        | .0110     | .27              | 35,000                        |
| December, .  | 500,000                                                             | 53                      | 54        | Slight.     | .20    | 0.0520   | .0420       | 8.25      | 2.10        | .0100     | .23              | 19,500                        |

Effluent of Filter No. 52 applied, 16½ gallons eighteen times a week, February 1 to May 1; 12½ gallons twenty-four times a week, May 2 to June 28; from June 29 to July 21, the amount of applied sewage varied from 3 gallons to 47½ gallons daily; 12½ gallons twelve times a week, July 22 to December 10. February 18, ½ inch of coke removed from surface of Filter No. 22 and thoroughly mixed with top foot of coke in Filter No. 58. April 15 to 21, experiment interrupted by freshet. Surface raked 3 inches deep once each week, April 1 to 22, and daily from April 23 to December 10.

*Summary of Filters 51 to 58 Inclusive.*

The following table gives the average analysis of the effluent of each filter for the entire period of operation : —

[Parts per 100,000.]

| NUMBER OF FILTER. | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|-------------------|---------------------------------------------------------------------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|                   |                                                                     |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrates. |                  |                                |
| 51,* . . . .      | 608,400                                                             | -      | 2.1766   | .3707       | 11.91     | 0.8700      | .1353     | 2.43             | 620,000                        |
| 52, . . . .       | 608,400                                                             | -      | 2.0816   | .2806       | 12.15     | 0.4900      | .0511     | 1.66             | 443,800                        |
| 53,* . . . .      | 698,900                                                             | .31    | .6177    | .0731       | 12.81     | 2.0000      | .0139     | .49              | 75,700                         |
| 54, . . . .       | 667,500                                                             | .26    | .7431    | .0672       | 12.56     | 1.6900      | .0045     | .41              | 11,300                         |
| 55,* . . . .      | 681,400                                                             | .45    | .8629    | .0992       | 13.01     | 1.9250      | .0215     | .71              | 145,000                        |
| 56, . . . .       | 694,700                                                             | .32    | .8600    | .0716       | 12.46     | 1.7900      | .0205     | .49              | 80,700                         |
| 57,* . . . .      | 703,900                                                             | .36    | .8366    | .0768       | 12.58     | 1.6453      | .0146     | .50              | 98,200                         |
| 58, . . . .       | 701,900                                                             | .30    | .6573    | .0594       | 12.22     | 1.6800      | .0096     | .36              | 89,300                         |

\* The filters marked with an asterisk belong to one series and those without a mark to the other. It will be observed that the series of which Filter No. 52 (coke) was the initial filter had effluents containing less organic matter and lower numbers of bacteria than the effluents of the series of which Filter No. 51 was the initial filter.

*Filter No. 59.*

This filter is one ten-thousandth of an acre in area, and contains, over the usual under-drains, 60 inches in depth of gravel stones of an effective size of 2.50 millimeters. Down through the middle of the filter an iron pipe 1 inch in diameter is passed, and the pipe reaches to within 6 inches of the bottom of the filter. The lower 6 inches of this pipe is perforated and to the top is attached an aspirator operated by the pressure of the city water supply. This filter was first put in operation April 1, 1895, and has received sewage at an average rate, up to Jan. 1, 1896, of 500,000 gallons per acre daily. The surface of the filter has been disturbed to a depth of 3 inches once each week and the applied sewage has uniformly disappeared immediately from the surface. From April 4 to September 2 the filter was aerated from 9 P.M. to 5 A.M. daily; from this date until November 1 the filter was not aerated; from November 1 until November 25 it was again aerated from 9 P.M. to 5 A.M.; from November 25 to December 7 there was no aëration, and from this last date to the end of the year it was again aerated from 9 P.M. to

5 A.M. When aëration was stopped in September the effluent of the filter contained 2.41 parts of nitrates in 100,000. The nitrates gradually became less and on October 30 were 1.35 parts in 100,000, and the quantity of albuminoid ammonia and oxygen consumed of the effluent had doubled. On November 12, twelve days after renewing aëration in the filter, the nitrates of the effluent had increased to 3.50 parts in 100,000 but the albuminoid ammonia and oxygen consumed of the effluent decreased very gradually. The second period of interruption of aëration did not affect the quality of the effluent. The following table gives the monthly averages of the analyses :—

*Monthly Averages of Analyses of Effluent of Filter No. 59.*

[Parts per 100,000.]

| 1895.        | Quantity Applied.<br>Gallons per Acre Daily for Six Days in a Week. | TEMPERATURE.<br>DEG. F. |           | APPEARANCE. |        | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|--------------|---------------------------------------------------------------------|-------------------------|-----------|-------------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|              |                                                                     | Sewage.                 | Effluent. | Turbidity.  | Color. | Fees.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |
| April, . .   | 500,000                                                             | 51                      | 45        | Great.      | 1.50   | 1.5000   | .3300       | 7.38      | 0.00        | .0000     | 2.30             | 1,848,000                      |
| May, . .     | 500,000                                                             | 62                      | 57        | Decided.    | .47    | 1.7440   | .1440       | 13.18     | 1.41        | .1760     | 1.02             | 236,000                        |
| June, . .    | 500,000                                                             | 72                      | 70        | Decided.    | .42    | 0.2070   | .0970       | 13.62     | 2.21        | .0305     | 0.80             | 225,000                        |
| July, . .    | 500,000                                                             | 71                      | 70        | Slight.     | .44    | 0.7200   | .2050       | 14.99     | 3.21        | .0152     | 1.10             | 404,000                        |
| August, . .  | 500,000                                                             | 73                      | 72        | Decided.    | .41    | 0.8680   | .1896       | 14.78     | 2.90        | .0416     | 0.98             | 444,000                        |
| September, . | 500,000                                                             | 69                      | 69        | Great.      | .57    | 1.2166   | .1933       | 14.56     | 1.55        | .0120     | 1.02             | 511,000                        |
| October, . . | 500,000                                                             | 56                      | 54        | Great.      | .68    | 1.7125   | .4150       | 11.39     | 1.45        | .2125     | 2.30             | 520,000                        |
| November, .  | 500,000                                                             | 54                      | 52        | Great.      | .75    | 1.2433   | .3966       | 10.46     | 2.00        | .5647     | 2.87             | 716,000                        |
| December, .  | 500,000                                                             | 45                      | 49        | Great.      | .61    | 0.9875   | .2950       | 7.83      | 2.01        | .1080     | 1.43             | 317,000                        |

Sewage applied, 54 gallons daily six days a week, April 1 to December 31. Sewage applied in the following manner: six doses of 5 gallons each applied in the forenoon and six doses of 4 gallons each in the afternoon. April 1, a piece of 1-inch pipe  $5\frac{1}{2}$  feet long, having holes bored in the lower 6 inches, was driven down through the center of filter; the lower end of the pipe is 6 inches above the bottom of the filter; a trap was attached to outlet. Filter aspirated eight hours each night, April 1 to September 1, November 1 to 24, December 7 to 31. April 10 to 21, experiment interrupted by freshet. April 21, 6 inches of gravel removed from filter, washed and replaced. Surface raked 3 inches deep once each week.

*Filter No. 60.*

This filter is one twenty-thousandth of an acre in area, and contains, over the usual under-drains, 60 inches in depth of sand of an effective size of 0.25 millimeter. To this filter has been applied, since September 8, the waste liquor resulting from cleansing rags in a paper mill by means of a boiling solution of caustic soda and lime. The rags cleaned are of all kinds and colors and the resulting liquor

is often very highly colored. It has been applied to the filter, at an average rate of 65,500 gallons per acre daily, without difficulty. The effluent of the filter, while greatly improved in appearance and analysis from the applied liquor, is still highly charged with organic matter in solution, and the degree of alkalinity of the liquor is apparently unfavorable to the development of the nitrifying organism in the filter.

*Average Analysis of Liquor applied to and Effluent from Filter No. 60.*

[Parts per 100,000.]

|                           | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|---------------------------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|                           | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |
| Applied liquor, . . . . . | 2.3000   | 4.1000      | 20.00     | .0000       | .0000     | 140.00           | -                              |
| Effluent, . . . . .       | 1.0850   | 2.2910      | 12.59     | .1050       | .0067     | 84.36            | 8,092,000                      |

*Filter No. 61.*

This filter is one twenty-thousandth of an acre in area, and contains, over the usual under-drains, 60 inches in depth of sand of an effective size of 0.25 millimeter. To this filter has been applied the waste liquor from scouring wool at an average rate, since September 8, of 17,000 gallons per acre daily. The results thus far obtained have shown that, while this liquor can be filtered through sand and a large percentage of its organic matters removed, yet it is with such difficulty, owing to clogging and necessary removal of the surface layers of the sand of the filter, that a preliminary treatment to remove a large part of the dirt and fatty matters before filtration is essential.

*Average Analysis of Liquor applied to and Effluent from Filter No. 61.*

[Parts per 100,000.]

|                           | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|---------------------------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|                           | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |
| Applied liquor, . . . . . | 17.3000  | 43.1000     | 60.13     | .0000       | .0000     | 232.00           | -                              |
| Effluent, . . . . .       | 27.8000  | 8.3000      | 47.00     | .2300       | .0000     | 90.00            | 30,000,000                     |

*Filters Nos. VI. and VII.*

Filter No. VI. contained 60 inches in depth of sand of an effective size of 0.25 millimeter, and Filter No. VII. contained the same depth of coke breeze. To these two filters the effluent of Filter No. 61 was applied at an average rate, from October 1 to January 1, of 50,000 gallons per acre daily. Each filter disposed of the applied liquor readily, but it passed through the 5 feet of filtering material with little or no change, the organic matters present being of a very stable character and the degree of alkalinity obtained prejudicial to nitrification.

*Average Analyses of Effluents of Filters Nos. VI. and VII.*

[Parts per 100,000.]

| NUMBER OF FILTER. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|-------------------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|                   | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |
| VI., . . . . .    | 19.5800  | 7.9000      | 72.23     | .2260       | .0112     | 76.60            | 264,728,000                    |
| VII., . . . . .   | 21.1700  | 8.3900      | 54.06     | .2200       | .0260     | 76.10            | 37,472,000                     |

*Filter No. VIII.*

This filter contains 5 feet in depth of sand of an effective size of 0.25 millimeter, and has received the supernatant liquid resulting from precipitating the fat and dirt out of the strong waste wool scouring liquor by means of calcium chloride. This treatment with calcium chloride gives an almost complete clarification of the liquor, and its strength after treatment, estimated by albuminoid ammonia determinations, is about the same as the effluent of Filter No. 61. Filter No. VIII. has disposed of this clarified liquor readily at an average rate of 100,000 gallons per acre daily, but it has passed through the 5 feet of sand with very little change.

*Average Analysis of Effluent of Filter No. VIII.*

[Parts per 100,000.]

| NUMBER OF FILTER. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Bacteria per Cubic Centimeter. |
|-------------------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|
|                   | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |
| VIII., . . . . .  | 11.1900  | 6.5400      | 65.00     | .1510       | .0953     | 53.63            | 720,000                        |



## FILTRATION OF WATER.

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The investigations upon the purification of water by sand filtration have been continued throughout the year, and the data obtained by the results from the experimental filters at the station have been supplemented and strengthened by observations of the practical operation and the results obtained from the large filter (2.5 acres in area) of the water works of the city of Lawrence. All of the experimental filters in operation during 1894 were continued during 1895, and three new filters were constructed, containing sand of a character not before used, namely, Filter No. 62, containing 4 feet in depth of beach sand of an effective size of 0.40 millimeter; Filter No. 63, containing 2 feet in depth of "Berkshire" sand of an effective size of 0.16 millimeter, and Filter No. 64, containing 1 foot in depth of the "Berkshire" sand.

The general plan of the investigations was the same as in 1894 and the number of bacteria in the applied river water and in the effluent of each filter was determined daily. *B. prodigiosus* has been applied to all the filters in known quantities and at stated intervals, and the percentage removal of this germ by the several filters is considered to show the bacterial purification of the water, as the percentage removal of the ordinary water bacteria of the applied water shows the bacterial efficiency of the various filters, as explained in the last annual report.

The following table gives the average results obtained from the filtration of Merrimack River water during the year by the various filters:—

Summary of Average Daily Bacterial Results obtained from the Experimental Filtration of Merrimack River Water.

| NUMBER OF FILTER. | Date of Construction. | Effective Size of Sand. (Millimeter.) | Uniformity Coefficient. | Depth of Material. (Inches.) | Method of Operation. | Average Rate of Filtration. Gallons per Acre Daily. | AVERAGE NUMBER OF BACTERIA PER CUBIC CENTIMETER IN |           | Average Per Cent, which the Number of Bacteria in the Effluent was of the Number of Bacteria in Applied Water. | Average Bacterial Efficiency. |
|-------------------|-----------------------|---------------------------------------|-------------------------|------------------------------|----------------------|-----------------------------------------------------|----------------------------------------------------|-----------|----------------------------------------------------------------------------------------------------------------|-------------------------------|
|                   |                       |                                       |                         |                              |                      |                                                     | Applied Water.                                     | Effluent. |                                                                                                                |                               |
| 3 B, . . . . .    | Sept. 23, 1893,       | 0.23                                  | 2.3                     | 60                           | Intermittent.        | 3,095,000                                           | 15,800                                             | 133       | 0.84                                                                                                           | 99.16                         |
| 7 A, . . . . .    | July 20, 1894,        | 0.26                                  | 3.7                     | 24                           | Continuous.          | 3,750,000                                           | 15,900                                             | 72        | 0.41                                                                                                           | 99.59                         |
| 8 A, . . . . .    | Sept. 26, 1893,       | 0.23                                  | 2.3                     | 60                           | Continuous.          | 3,576,000                                           | 16,800                                             | 43        | 0.27                                                                                                           | 99.73                         |
| 18 A,* . . . . .  | Sept. 17, 1899,       | 0.48                                  | 2.4                     | 60                           | Intermittent.        | 4,500,000                                           | 16,500                                             | 72        | 0.43                                                                                                           | 99.57                         |
| 33 A, . . . . .   | April 28, 1892,       | 0.14                                  | 2.2                     | 60                           | Continuous.          | 1,980,000                                           | 16,300                                             | 84        | 0.51                                                                                                           | 99.49                         |
| 38, . . . . .     | April 28, 1892,       | 0.20                                  | 1.6                     | 18                           | Continuous.          | 940,000                                             | 11,600                                             | 59        | 0.50                                                                                                           | 99.50                         |
| 41, . . . . .     | May 9, 1892,          | 0.14                                  | 2.2                     | 60                           | Intermittent.        | 1,960,000                                           | 11,600                                             | 29        | 0.25                                                                                                           | 99.76                         |
| 42, . . . . .     | Oct. 29, 1892,        | 0.20                                  | 1.6                     | 7                            | Continuous.          | 4,460,000                                           | 16,500                                             | 898       | 6.44                                                                                                           | 94.56                         |
| 43,† . . . . .    | May 20, 1893,         | 0.26                                  | 3.7                     | 60                           | Continuous.          | 4,680,000                                           | 16,500                                             | 191       | 1.16                                                                                                           | 98.84                         |
| 44,† . . . . .    | May 20, 1893,         | 0.29                                  | 2.7                     | 52                           | Continuous.          | 6,780,000                                           | 11,600                                             | 73        | 0.63                                                                                                           | 99.37                         |
| 45,† . . . . .    | July 10, 1893,        | 0.23                                  | 2.3                     | 57                           | Intermittent.        | 4,520,000                                           | 16,500                                             | 207       | 1.26                                                                                                           | 98.74                         |
| 46, . . . . .     | Aug. 21, 1893,        | 0.29                                  | 2.3                     | 10                           | Continuous.          | 4,480,000                                           | 11,600                                             | 122       | 1.05                                                                                                           | 98.95                         |
| 47,† . . . . .    | Sept. 9, 1893,        | 0.29                                  | 2.4                     | 51                           | Intermittent.        | 6,000,000                                           | 11,600                                             | 72        | 0.62                                                                                                           | 99.38                         |
| 48, . . . . .     | Sept. 9, 1893,        | 0.38                                  | 3.5                     | 51                           | Continuous.          | 4,280,000                                           | 16,500                                             | 81        | 0.49                                                                                                           | 99.51                         |
| 49, . . . . .     | Sept. 9, 1893,        | 0.38                                  | 3.5                     | 56                           | Continuous.          | 8,200,000                                           | 16,500                                             | 130       | 0.78                                                                                                           | 99.22                         |
| 50,* . . . . .    | July 23, 1894,        | 0.48                                  | 2.4                     | 58                           | Continuous.          | 4,680,000                                           | 16,500                                             | 92        | 0.55                                                                                                           | 99.45                         |
| 62, . . . . .     | Sept. 2, 1895,        | 0.40                                  | 1.9                     | 48                           | Continuous.          | 4,700,000                                           | 24,300                                             | 262       | 1.07                                                                                                           | 98.93                         |
| 63, . . . . .     | Sept. 2, 1895,        | 0.16                                  | 2.3                     | 24                           | Continuous.          | 4,580,000                                           | 24,300                                             | 584       | 2.31                                                                                                           | 97.69                         |
| 64, . . . . .     | Sept. 2, 1895,        | 0.16                                  | 2.3                     | 12                           | Continuous.          | 4,520,000                                           | 24,300                                             | 389       | 1.60                                                                                                           | 98.40                         |

\* Reduced in depth to 36 inches August 31.

† Reduced in depth to 36 inches August 1.

## DISCUSSION OF BACTERIAL EFFICIENCY OF THE FILTERS.

We see by this table that the average bacterial efficiency of the filters during 1895 has (excluding the results obtained from Filter No. 42, which has contained for a portion of its period of operation only 1 inch in depth of sand) varied from 97.69 per cent. on the part of Filter No. 63 to 99.75 per cent. on the part of Filter No. 41. Filter No. 63 was, in common with filters No. 62 and 64, a new filter, having been operated only three months at the time the averages were made, and containing but 2 feet in depth of sand. Excluding from the averages of the year filters Nos. 42, 62, 63 and 64, for the reasons given, the bacterial efficiency of the remaining filters — filters which had been in operation for a period during 1894 and earlier years — varies from 98.74 per cent. on the part of Filter No. 45 to 99.75 per cent. on the part of Filter No. 41. All the filters, with the exception of filters Nos. 3 B, 7 A and 8 A, are  $\frac{1}{20}$  of an acre in area and within the buildings. These small filters cannot be operated during the winter months on account of complications from freezing, which causes the formation of channels between the body of the sand and the sides of the iron tanks, and on account of the evolution of air from the saturated water within the filters. These facts have been thoroughly explained in previous reports, and it is enough at this time to state that they are simply effects of the location of these small experimental filters and not factors in filtration. Filters Nos. 3 B, 7 A and 8 A are located out of doors and are each  $\frac{1}{20}$  of an acre in area. Filter No. 3 B is an intermittent filter and Filter No. 8 A is a continuous filter, and both have been operated constantly since their construction, Sept. 23, 1893; and, although they are not protected from the weather, as filters in this climate undoubtedly should be, the results from them are probably the most important obtained at the experiment station, and illustrate more completely than the results of operation of the other filters the average yearly bacterial efficiency that can be obtained by filters containing 5 feet in depth of medium sand and operating at normal rates.

The average daily number of bacteria per cubic centimeter in the effluent of Filter No. 3 B for the year is shown by the table on page 532, and a similar table on page 538 gives the same information in regard to the effluent of Filter No. 8 A. In studying these results month by month we learn in the case of Filter No. 3 B (intermittent)

the following facts: the average bacterial efficiency of the year was 99.16 per cent., but on several occasions during the winter months the bacterial efficiency was low. On January 8 the surface of the filter was raked to the depth of 1 inch to remove clogging, and the filter was subsequently put in operation by filling from above with canal water, and on January 9 and 10 the bacterial efficiency of the filter was 91.70 and 96.50 per cent. respectively, but on no other day of the month was its efficiency less than 98 per cent. From February 6 until February 12, inclusive, owing to a frozen feed-pipe, the filter stood uncovered with water and became frozen to a considerable depth. The bacterial results of the next few days were of course poor, and should hardly be included in the yearly averages. During the winter months, up to March 11, the filter had been operated at a rate of 1,500,000 gallons per acre daily, but on this date, owing to an increased supply of water, the rate was increased to 5,000,000 gallons per acre daily, and this rate continued until November 24. For the six days following this increase of rate the bacterial efficiency averaged 94.85 per cent., but from this time throughout the remainder of the year the daily bacterial efficiency was never less than 98 per cent., and for months at a time was 99.50 per cent. or more. The comparatively low bacterial efficiency obtained at times during the winter months was largely due to the exposure of the surface of the sand to extremely cold weather, and could be avoided to a large extent with covered filters.

Studying the bacterial results of Filter No. 8 A (continuous), given in the table on page 538, we find that its daily bacterial efficiency for the year was 99.73 per cent. Throughout January and February and the first eleven days of March this filter, although exposed to the weather, gave a bacterial efficiency that was on no occasion less than 99.35 per cent. During this period the filter was operating at a rate of 1,500,000 gallons per acre daily. On March 11, owing to an increased water supply, the rate of filtration was increased to 5,000,000 gallons per acre daily, and this rate continued until November 25. For a period of eight days following this increase of rate, that is, from March 12 to 19 inclusive, the bacterial efficiency of the filter averaged 96.30 per cent., with a minimum efficiency of 92.30 per cent. From this last date until the close of the year the bacterial efficiency of the filter was never less than 98 per cent., and only on two or three occasions less than 99 per cent., and for months at a time maintained a uniform efficiency of 99.50 per cent. or more.

The bacterial results obtained from these large filters upon October 3 and 4 are significant when compared with the results obtained on these days from the small filters. On these two days the number of bacteria in the applied water was 319,000 and 110,000 per cubic centimeter, respectively, and in Filter No. 3 B, 233 and 90, Filter No. 7 A, 24 and 55, and Filter No. 8 A, 22 and 7 per cubic centimeter, respectively. The effluents of the small filters all contained a much larger number of bacteria per cubic centimeter upon these days.

*Bacterial Efficiency of the Small In-door Filters.*

These filters, as has been stated, can be operated only a portion of the year, and have been largely used during 1894 and 1895 in studying the bacterial results obtained from filters of different depths, material and period of operation when they are subjected to fluctuations of rate of filtration, deep scrapings, raking, etc., and have consequently been operated in many instances in a manner known to be unfavorable to the greatest average bacterial efficiency. In the tables given in a subsequent portion of this report and showing the daily bacterial efficiency of filters No. 18 to 64, inclusive, the bacterial results of those days when the filters were subjected to abnormal treatments are of samples taken before such treatment.

The average daily bacterial results of the following day were, however, necessarily affected in many instances. For this reason the results are not considered to be as representative as the results from filters Nos. 3 B and 8 A. Another complication entering into the summarizing of the results of these small filters is the fact that, in the middle of their period of operation during 1895, those containing approximately 5 feet in depth of sand were cut down to a depth of 3 feet. All of these filters, that contained at the beginning of their period of operation in 1895, 5 feet in depth of filtering material, gave a bacterial efficiency varying from 98.74 per cent. to 99.75 per cent., operating at rates of filtration varying from 2,000,000 to 7,000,000 gallons per acre daily. Filter No. 38, containing approximately 20 inches in depth of sand, and operating at an average rate of 940,000 gallons per acre daily, had a bacterial efficiency of 99.50 per cent., and Filter No. 46, containing approximately 12 inches in depth of sand, and operating at the rate of 4,480,000 gallons per acre daily, had a bacterial efficiency of 98.95 per cent.

In calculating the bacterial efficiency of these small filters the results obtained during the first ten days of their operation, or period of biological construction, are omitted.

*Bacterial Purification.*

The chief object of water filtration is the removal of disease germs. The results of filtration for the year, given in the preceding table and discussion, are entirely confined to the removal of the bacteria normally present in the Merrimack River water as it flows past Lawrence, after receiving the sewage of Lowell, Manchester, Concord and many other cities and towns upon its water-shed. These bacteria are of many kinds, and are chiefly those found in the wastes of human and animal life together with many whose natural habitat is the river water. To strengthen and confirm the results obtained by sand filtration of this water, it has been the custom for the past few years at the station to add at times to the water applied to the filters a pure culture of *B. prodigiosus*. The reasons for the application of this germ are that it is apparently incapable of growth within the filters and their under-drains, can be readily detected if present in the effluents, and hence its percentage removal by the filters more definitely determined than the percentage removal of the various kinds of bacteria normally present in the applied water. Some of these bacteria, we have been led to believe by results obtained in former years, are capable of multiplying within the filters, and in this manner preventing the number of bacteria present in the effluent representing the number which have passed through the entire filter. The tables showing the number of *B. prodigiosus* in the applied water and in the effluents of the various filters are given on page 529 and following pages. In studying these tables we see that the bacterial purification obtained by the various filters has been much greater than their bacterial efficiency. The bacterial purification results obtained from filters Nos. 3 B and 8 A may be summarized as follows: the rate of filtration of Filter No. 3 B was increased March 11 from 1,500,000 gallons to 5,000,000 gallons per acre daily, and on this day *B. prodigiosus* was first applied. Each cubic centimeter of applied canal water upon this day contained 617, and on the five following days 500, 970, 1,882, 870 and 244 germs of *B. prodigiosus*, respectively, and each cubic centimeter of the effluent contained on these days 5, 10, 5, 5, 2 and 1, respectively, showing an average bacterial purification for these days of 94.50 per cent. The application of *B. prodigiosus* was continued at the same rate until April 10, but only once after March 16 was its presence detected in the effluent. Such a great fluctuation of rate as that given

above, and which resulted in low bacterial efficiency and purification, is not a necessary occurrence in natural sand filtration, and the results obtained must be regarded as abnormal.

From September 2 to November 21, when the filter was operating normally at a 5,000,000 gallon rate, *B. prodigiosus* was again applied in the same proportion for ten hours daily and on only five days was its presence detected in the effluent. The bacterial purification obtained by the filter during these three months was 99.99+ per cent. This same germ was applied in the same proportion to Filter No. 8 A from March 11 to April 10, and the rate of operation of this filter was increased to the same extent on March 12 as that of Filter No. 3 B. It is of interest to note that on March 11 this germ did not appear in the effluent, but that on March 12, the day on which the rate was increased 70 per cent., the effluent contained 41 per cubic centimeter, and its presence was noted upon fifteen of the days upon which it was applied up to April 10. The average bacterial purification of the filter during the first six days of its application was 87.9 per cent. and for the remaining period up to April 10 was 99.85 per cent.

From May 6 to November 19, and from this last date until December 1, during which entire period the filter was running normally at a rate of 5,000,000 gallons per acre daily, *B. prodigiosus* was applied up to November 19 in the same proportion as during the period from March 11 to April 10, and from November 19 to December 1 in numbers twice as great, and on only five days in this entire period was its presence detected in the effluent of this filter, giving a bacterial purification of 99.99+ per cent.

Filter No. 7 A of the same area as filters Nos. 3 B and 8 A, but containing only 2 feet in depth of a somewhat coarser sand, had *B. prodigiosus* applied to it in the same proportion as to filters Nos. 3 B and 8 A ten hours daily, from August 20 to November 19 inclusive, during which period the filter was filtering at a rate of 5,000,000 gallons per acre daily, and the presence of the germ was detected in the effluent upon sixteen days. Of these sixteen days twelve were of the first three or four days following scraping to remove clogging of the surface of the filter.

The bacterial purification obtained by the small in-door filters has been uniformly greater than their bacterial efficiency.

*Increased Effectiveness of Filters due to Age or Length of Period of Service.*

Bacterial results have been given from time to time tending to show that the bacterial efficiency of sand filters increased in proportion to their period of service. This tendency towards increased effectiveness with increased age is made more clear by the results obtained during the past year (1895) from those filters which have been in operation at the station for several years. This increased efficiency of the filters is probably due to the accumulation of organic and mineral matter of a gelatinous character upon the sand grains of the filter, together with an increased compactness of the sand caused by a moderate amount of settling. Filter No. 18 A, the oldest filter in use at the station during 1895, and one of the two filters with greatest effective size of sand grain, was in operation during 1893 at an average rate of about 2,000,000 gallons per acre daily, and its bacterial efficiency was 96.75 per cent. During 1894 its rate of operation was 4,500,000 gallons per acre daily and its efficiency was 98.97 per cent., and during 1895 it has been operating approximately at the same rate as during 1894, and its bacterial efficiency has been 99.57 per cent. This increased bacterial efficiency caused by length of period of service is considerably more marked with filters constructed of medium coarse or coarse sands than it is with those constructed of medium fine sand. The following table of results from filters, all of which were constructed during 1893, is interesting as bearing upon this point. All of these filters contained during 1893 and 1894 5 feet in depth of sand, but Aug. 1, 1895, filters Nos. 43, 44, 45 and 46 were reduced in depth to 3 feet.

*Table showing the Bacterial Efficiency of Filters during Successive Years of their Period of Service.*

| NUMBER<br>OF<br>FILTER. | Date of<br>Construction. | Effective<br>Size of<br>Sand.<br>—<br>Millimeter. | 1893.                             |                                                                                                                   | 1894.                             |                                                                                                                   | 1895.                             |                                                                                                                   |
|-------------------------|--------------------------|---------------------------------------------------|-----------------------------------|-------------------------------------------------------------------------------------------------------------------|-----------------------------------|-------------------------------------------------------------------------------------------------------------------|-----------------------------------|-------------------------------------------------------------------------------------------------------------------|
|                         |                          |                                                   | Average<br>Rate of<br>Filtration. | Average<br>Per Cent.<br>which<br>Number of<br>Bacteria<br>in Effluent<br>was of<br>Number<br>in Applied<br>Water. | Average<br>Rate of<br>Filtration. | Average<br>Per Cent.<br>which<br>Number of<br>Bacteria<br>in Effluent<br>was of<br>Number<br>in Applied<br>Water. | Average<br>Rate of<br>Filtration. | Average<br>Per Cent.<br>which<br>Number of<br>Bacteria<br>in Effluent<br>was of<br>Number<br>in Applied<br>Water. |
|                         |                          |                                                   | Gallons<br>per Acre<br>Daily.     |                                                                                                                   | Gallons<br>per Acre<br>Daily.     |                                                                                                                   | Gallons<br>per Acre<br>Daily.     |                                                                                                                   |
| 43, . .                 | May 20, 1893,            | 0.26                                              | 4,848,000                         | 1.07                                                                                                              | 4,740,000                         | 1.16                                                                                                              | 4,680,000                         | 1.16                                                                                                              |
| 44, . .                 | May 20, 1893,            | 0.29                                              | 4,940,000                         | 0.60                                                                                                              | 7,370,000                         | 0.70                                                                                                              | 6,780,000                         | 0.63                                                                                                              |
| 45, . .                 | July 10, 1893,           | 0.23                                              | 2,220,000                         | 2.25                                                                                                              | 4,790,000                         | 0.54                                                                                                              | 4,320,000                         | 1.26                                                                                                              |
| 46, . .                 | Aug. 21, 1893,           | 0.29                                              | 2,400,000                         | 0.99                                                                                                              | 2,353,000                         | 0.38                                                                                                              | 4,480,000                         | 1.05                                                                                                              |
| 47, . .                 | Sept. 9, 1893,           | 0.29                                              | 3,580,000                         | 3.41                                                                                                              | 6,345,000                         | 1.22                                                                                                              | 6,600,000                         | 0.62                                                                                                              |
| 48, . .                 | Sept. 9, 1893,           | 0.38                                              | 2,280,000                         | 3.52                                                                                                              | 4,730,000                         | 2.72                                                                                                              | 4,280,000                         | 0.49                                                                                                              |
| 49, . .                 | Sept. 9, 1893,           | 0.38                                              | 3,800,000                         | 0.81                                                                                                              | 9,700,000                         | 2.28                                                                                                              | 8,200,000                         | 0.78                                                                                                              |



*Effect of Different Depths of Filtering Material upon Bacterial Efficiency.*

If filters 2 or 3 feet in depth can by careful supervision produce as uniformly satisfactory results from a hygienic point of view as filters containing 5 feet in depth of filtering material, their cost of construction would be materially lessened. The results attained at the station have indicated that nearly as satisfactory results are given by shallow filters as by deeper ones, especially after a period of service of some considerable length, but that they are much more sensitive to disturbing influences. This really means that if a filter in practical operation is to be supervised by experts, satisfactory and safe results can be secured with a shallow depth of sand, but that if its operation is to be entrusted to unskilled hands, not fully acquainted with the essential features of successful sand filtration, the steadying influence of a considerable depth of sand is all important. This is especially so in winter, when formation of ice and freezing of the surface sand is liable to occur, as at such times the best and most skilful handling would be necessary, with a shallow filter, to produce satisfactory results. The depth of sand in the Lawrence city filter and the method of under-draining, by which the rapidity of filtration is checked, have undoubtedly been of extreme value in producing good hygienic results.

To make a really just comparison between filters of different depths of filtering material, the filters should be of the same grade of sand, of the same period of service and should have been operated at the same rate. We can make no such absolute comparison of any of the filters in operation during 1895, but a comparison of some value can be shown by the following table of results of the three days preceding and three days following scraping the surfaces of filters Nos. 7 A and 8 A. It can also be stated that scraping the surface of Filter No. 8 A did not affect the bacterial purification results obtained, while scraping the surface of Filter No. 7 A almost invariably caused the appearance of *B. prodigiosus* in the effluent for the three or four days following.

The second table shows the number of bacteria in the effluents of these two filters at periods between scraping, when the filters were operating at approximately the same rate, namely, 5,000,000 gallons per acre daily.

Table showing the Effect of Scraping Filters Two Feet and Five Feet Deep.

| DATE OF<br>SCRAPING. | FILTER NO. 7A, 2 FEET DEEP.                                                |                                           |                                                                       |                                           | DATE OF<br>SCRAPING. | FILTER NO. 8A, 5 FEET DEEP.                                                |                                           |                                                                       |                                           |
|----------------------|----------------------------------------------------------------------------|-------------------------------------------|-----------------------------------------------------------------------|-------------------------------------------|----------------------|----------------------------------------------------------------------------|-------------------------------------------|-----------------------------------------------------------------------|-------------------------------------------|
|                      | AVERAGE NUMBER<br>OF BACTERIA PER<br>CUBIC CENTIMETER<br>IN APPLIED WATER. |                                           | AVERAGE NUMBER<br>OF BACTERIA PER<br>CUBIC CENTIMETER<br>IN EFFLUENT. |                                           |                      | AVERAGE NUMBER<br>OF BACTERIA PER<br>CUBIC CENTIMETER<br>IN APPLIED WATER. |                                           | AVERAGE NUMBER<br>OF BACTERIA PER<br>CUBIC CENTIMETER<br>IN EFFLUENT. |                                           |
|                      | Average of Three<br>Days pre-<br>ceding.                                   | Average of Three<br>Days suc-<br>ceeding. | Average of Three<br>Days pre-<br>ceding.                              | Average of Three<br>Days suc-<br>ceeding. |                      | Average of Three<br>Days pre-<br>ceding.                                   | Average of Three<br>Days suc-<br>ceeding. | Average of Three<br>Days pre-<br>ceding.                              | Average of Three<br>Days suc-<br>ceeding. |
| 1895.                |                                                                            |                                           |                                                                       |                                           | 1895.                |                                                                            |                                           |                                                                       |                                           |
| May 16, .            | 7,300                                                                      | 9,800                                     | 21                                                                    | 137                                       | May 23, .            | 6,000                                                                      | 5,000                                     | 44                                                                    | 20                                        |
| June 4, .            | 17,200                                                                     | 15,000                                    | 26                                                                    | 82                                        | June 29, .           | 19,000                                                                     | 13,000                                    | 34                                                                    | 23                                        |
| June 26, .           | 11,000                                                                     | 19,000                                    | 123                                                                   | 115                                       | July 12, .           | 26,000                                                                     | 24,000                                    | 28                                                                    | 25                                        |
| July 17, .           | 26,000                                                                     | 24,000                                    | 34                                                                    | 121                                       | Oct. 17, .           | 15,000                                                                     | 6,500                                     | 12                                                                    | 28                                        |
| Aug. 27, .           | 5,300                                                                      | 5,200                                     | 29                                                                    | 235                                       | Oct. 28, .           | 3,500                                                                      | 4,000                                     | 11                                                                    | 6                                         |
| Sept. 7, .           | 9,000                                                                      | 4,000                                     | 32                                                                    | 78                                        | Nov. 12, .           | 4,000                                                                      | -                                         | 11                                                                    | 17                                        |
| Sept. 26, .          | 11,000                                                                     | 11,000                                    | 40                                                                    | 50                                        |                      |                                                                            |                                           |                                                                       |                                           |
| Oct. 12, .           | 180,000                                                                    | 18,000                                    | 21                                                                    | 195                                       |                      |                                                                            |                                           |                                                                       |                                           |
| Oct. 22, .           | 2,600                                                                      | 3,800                                     | 68                                                                    | 63                                        |                      |                                                                            |                                           |                                                                       |                                           |
| Nov. 12, .           | 4,000                                                                      | -                                         | 10                                                                    | 92                                        |                      |                                                                            |                                           |                                                                       |                                           |

Table showing the Number of Bacteria per Cubic Centimeter in the Effluent of Filters Nos. 8 A and 7 A at Periods between Scraping, when the Filters were operating at Approximately the same Rate.

| DATE.             | Filter No. 8 A. | Filter No. 7 A. | DATE.             | Filter No. 8 A. | Filter No. 7 A. |
|-------------------|-----------------|-----------------|-------------------|-----------------|-----------------|
| July 16, . . . .  | 22              | -               | August 4, . . . . | -               | -               |
| 19, . . . .       | 12              | 64              | 5, . . . .        | 96              | 50              |
| 20, . . . .       | 28              | -               | 6, . . . .        | 13              | 74              |
| 21, . . . .       | -               | 58              | 7, . . . .        | 10              | -               |
| 22, . . . .       | 16              | 43              | 8, . . . .        | 12              | -               |
| 23, . . . .       | 27              | 24              | 9, . . . .        | 8               | 42              |
| 24, . . . .       | 11              | 32              | 10, . . . .       | 10              | 35              |
| 25, . . . .       | 23              | 35              | 11, . . . .       | -               | -               |
| 26, . . . .       | 23              | 25              | 12, . . . .       | 23              | 24              |
| 27, . . . .       | 19              | -               | 13, . . . .       | 16              | 62              |
| 28, . . . .       | -               | 29              | 14, . . . .       | 26              | 63              |
| 29, . . . .       | 24              | 43              | 15, . . . .       | 19              | 33              |
| 30, . . . .       | 22              | 25              | 16, . . . .       | 7               | 27              |
| 31, . . . .       | 13              | 30              | 17, . . . .       | 13              | 30              |
| August 1, . . . . | 15              | 20              | 18, . . . .       | -               | -               |
| 2, . . . .        | 14              | 22              | 19, . . . .       | 6               | 38              |
| 3, . . . .        | -               | 21              | 20, . . . .       | 6               | 16              |

On August 1, filters Nos. 43, 44, 45 and 47, which contained, when first constructed in 1893, 5 feet in depth of sand, but which had grown gradually shallower by the removal of sand at times of scraping, were cut down to the extent necessary to cause them to contain 3 feet in depth of sand over their under-drains. On August 31, filters Nos. 18 A and 50 were treated in a like manner. To reduce them to the required depth it was necessary to remove a foot or more of sand.

The purpose of this reduction in depth was to study and compare the results obtained from the same filters when of different depths, but this purpose was defeated to some extent by the fact that in removing so great a depth of filtering material, which had been rendered doubly effective by the organic matter accumulated within it, we were practically establishing new filters. The results obtained from them therefore could not in fairness be compared with the results just previously obtained, when the filters were of greater depth; neither could they be compared with results obtained during the first few months of operation of these filters, as at that time there was practically no organic matter or gelatinous films upon the sand grains, while of course on the sand remaining in the filters after their reduction in depth these gelatinous films were present to a considerable extent. It can be said, however, that these filters, after a period of biological construction, gave nearly as great bacterial efficiency under normal conditions of filtration, but were more sensitive to disturbing influences. A fairer comparison can be made between filters Nos. 46 and 47. Filter No. 46, containing approximately 12 inches in depth of sand of an effective size of 0.29 millimeter, had a bacterial efficiency for the year of 98.95 per cent., with an average rate of filtration of 4,480,000 gallons per acre daily, while Filter No. 47, containing approximately 60 inches in depth of sand of the same grade up to August 1, and after this date 36 inches in depth of sand, had a bacterial efficiency for the year of 99.38 per cent., with an average rate of filtration of 6,600,000 gallons per acre daily. From May 1 to August 1 Filter No. 46 was scraped ten times to remove clogging; the depth of sand removed at each scraping averaged 0.41 of an inch, and the average number of bacteria per cubic centimeter in the effluent for the twenty-four hours following these scrapings was 209. Filter No. 47 was scraped thirteen times to remove clogging between May 1 and August 1; the depth of sand removed each time averaged 0.33 of an inch, and the average number of bacteria in

each cubic centimeter of the effluent for the twenty-four hours following scraping averaged 86. These two filters are of the same age.

*The Effect of the Amount of Loss of Head upon Bacterial Efficiency.*

It has been stated in the last two reports that, contrary to some European experience, the experimental filters at Lawrence under ordinary conditions show no diminution in the removal of bacteria when the loss of head, or measurement of the frictional resistance of the sand of the filter to the passage of water, reaches nearly or quite the total depth of the filter (sand and water). The results obtained for 1895 from filters operating under normal conditions emphatically confirm the earlier ones. In studying the bacterial efficiency of the various filters when their loss of head was at or approaching its maximum, occasional results can be found giving slightly higher numbers of bacteria, but generally not enough higher to lower the bacterial efficiency of the filter more than a small fraction of one per cent. If we take the results obtained from filters Nos. 3 B, 7 A and 8 A to represent the results obtained by filters operating under normal conditions, we learn the following facts regarding this point: Filter No. 3 B was scraped ten times during 1895 to remove clogging and keep the rate to the prescribed limit; that is to say, the loss of head reached its maximum ten times, but the lowest bacterial efficiency obtained at any time upon the day immediately preceding scraping was 99.25 per cent. Filter No. 8 A was scraped sixteen times during the year, and the lowest bacterial efficiency obtained at any time upon the day immediately preceding scraping was 99.22 per cent. Filter No. 7 A contains but 2 feet in depth of sand and was scraped twelve times during its period of operation in 1895, and its lowest bacterial efficiency upon any day immediately preceding scraping was 98.90 per cent.

*Effect of Fluctuation in Rate upon Bacterial Efficiency.*

Under the discussion of the bacterial efficiency obtained during the year by filters Nos. 3 B and 8 A on page 506, the poor results obtained for a few days in March, following the increase of rate of each filter from 1,500,000 to 5,000,000 gallons per acre daily, has been noted. At the time when these increments of rate were made the filters had been scraped to a depth of 1 inch and then raked to a depth of 1 inch. This was a combination of factors well calcu-

lated to produce low efficiency and not necessary in actual filtration. It has been shown by the table on page 513 that scraping Filter No. 8 A had little if any effect upon its bacterial efficiency, and many thousand samples of the effluents of intermittent filters, taken after flooding and when the rates of filtration of the filters were slowly increasing to the maximum, prove that rates may be greatly increased without diminishing bacterial efficiency.

Violent fluctuations of rate, either above or below the normal, produce mechanical disturbances of the filtering materials and diminished bacterial efficiency for periods more or less prolonged.

The following table records some results obtained by fluctuating the rates of filtration. The number of bacteria per cubic centimeter in the effluents before the changes were made are given, together with the maximum number found after the change. Each set of results represents from ten to twenty bacterial analyses of samples of the effluent, most of which were collected at about the time when the water, which was in the upper portion of the filter when the rate was changed, was flowing from the filter.

*Summary of Bacterial Results to show the Effect of Fluctuating the Rate of Filtration.*

| NUMBER OF FILTER. | DATE.<br>1895. | CHANGES IN<br>RATE.                   | NUMBER OF BACTERIA PER<br>CUBIC CENTIMETER IN<br>EFFLUENT. |                            |
|-------------------|----------------|---------------------------------------|------------------------------------------------------------|----------------------------|
|                   |                | Million<br>Gallons per<br>Acre Daily. | Before<br>Change.                                          | After Change<br>(Maximum). |
| 18, . . . . .     | Nov. 22,       | 7-15                                  | 131                                                        | 185                        |
| 33, . . . . .     | Oct. 10,       | -                                     | 180                                                        | 426                        |
| 33, . . . . .     | Nov. 22,       | 2-15                                  | 46                                                         | 43                         |
| 43, . . . . .     | Oct. 7,        | 5.5-19                                | 132                                                        | 143                        |
| 43, . . . . .     | Nov. 9,        | 5-24-5                                | 136                                                        | 250                        |
| 45, . . . . .     | Nov. 12,       | 6-16                                  | 87                                                         | 95                         |
| 45, . . . . .     | Nov. 22,       | 6-12                                  | 96                                                         | 167                        |
| 48, . . . . .     | Oct. 9,        | 5-6.5                                 | 132                                                        | 490                        |
| 48, . . . . .     | Oct. 16,       | 5-7.5                                 | 60                                                         | 92                         |
| 48, . . . . .     | Oct. 21,       | 5-6                                   | 35                                                         | 60                         |
| 48, . . . . .     | Oct. 26,       | 5-7.5                                 | 55                                                         | 81                         |
| 49, . . . . .     | Oct. 16,       | 9.5-18                                | 65                                                         | 110                        |
| 49, . . . . .     | Oct. 26,       | 10-12-10                              | 64                                                         | 94                         |
| 50, . . . . .     | Oct. 7,        | 5-8                                   | 72                                                         | 73                         |
| 50, . . . . .     | Oct. 26,       | 5-14-5                                | 93                                                         | 150                        |

In making these experiments the outlets of the filters were in most instances opened quickly and allowed to remain open, but occasionally, as with Filter No. 43 on November 9, the faucet was opened quickly, allowed to remain so for a few minutes and then closed to its original position. The experiments were all made during the months of October and November, and during October the number of bacteria in the applied canal water was unusually high. On October 10, the day on which the rate of Filter No. 33 was first fluctuated, as given in the table, the number of bacteria in the applied canal water was 298,000, and on October 9, the day on which the rate of Filter No. 48 was first fluctuated, the number in the canal water was 126,000 per cubic centimeter.

### *High Rates of Filtration.*

The longer the investigations upon water filtration have been continued, the more evident it has become that entirely satisfactory bacterial purification of water can be obtained at rates of filtration much greater than formerly supposed. If the results obtained at the station during the past two or three years have decided anything they have certainly made this point clear. It has also been decisively settled that the bacterial efficiency of natural sand filters increases with age, and that a growing municipality that decides to filter its water supply through sand can reckon upon increasing the volume of water filtered through a given area of filter bed as the filter grows older, and obtain a bacterial efficiency equal to that obtained at the beginning of operation of its filter. Entirely satisfactory results were obtained during 1895 from filters operating at rates of 5,000,000 and even 7,000,000 gallons per acre daily. The results from filters Nos. 3 B and 8 A have been mentioned on previous pages, and the average bacterial efficiency of all the filters, together with their rates of operation, have been given in the first table of this report.

Increasing the rates of individual filters from year to year has not resulted in decreased bacterial efficiency, but the increase of period of service of these filters has been partly accountable for the entirely satisfactory results obtained. An interesting experiment has been made with filters Nos. 48 and 49. These two filters each contain approximately 5 feet in depth of sand of an effective size of 0.38 millimeter and were constructed at the same time. During 1894 and 1895 Filter No. 49 has been operated at a rate approximately

twice as great as the rate of operation of Filter No. 48, and the bacterial efficiency of these two filters, together with their rate of filtration, is given in a following table. The results are interesting as showing that a filter can be operated at a rate of more than 9,000,000 gallons per acre daily and maintain an average bacterial efficiency of more than 99 per cent.

There is one instance recorded which deserves explanation. During October, 1895, the average number of bacteria in the effluent of Filter No. 49 was 533. In order to maintain the high rate of filtration it was necessary to scrape this filter very frequently during October, and as the average number of bacteria in the applied canal water was unusually high on several occasions, they caused high numbers in the effluent. For instance, on October 3 there were 319,000 bacteria per cubic centimeter in the applied water and 2,086 in the effluent. On October 9, 12 and 15 the filter was scraped, and on these days there were 126,000, 147,000 and 17,000 bacteria per cubic centimeter in the applied water and 1,050, 4,753 and 152 bacteria per cubic centimeter in the effluent.

The filter at this time was running at an average rate of filtration of nearly 10,000,000 gallons per acre daily. Filter No. 48, operating at a rate of 5,000,000 gallons per acre daily, was much less affected by these high numbers of bacteria in the applied water.

*Table to show the Relative Efficiency of Filters operating at High, as compared with those operating at Lower, Rates of Filtration.*

| DATE.          | Average<br>Number of<br>Bacteria<br>in the<br>Applied<br>Water. | FILTER No. 48.                                                            |                                                         |                          | FILTER No. 49.                                                            |                                                         |                          |
|----------------|-----------------------------------------------------------------|---------------------------------------------------------------------------|---------------------------------------------------------|--------------------------|---------------------------------------------------------------------------|---------------------------------------------------------|--------------------------|
|                |                                                                 | Average<br>Rate of Fil-<br>tration.<br>—<br>Gallons<br>per Acre<br>Daily. | Average<br>Number of<br>Bacteria<br>in the<br>Effluent. | Bacterial<br>Efficiency. | Average<br>Rate of Fil-<br>tration.<br>—<br>Gallons<br>per Acre<br>Daily. | Average<br>Number of<br>Bacteria<br>in the<br>Effluent. | Bacterial<br>Efficiency. |
|                |                                                                 |                                                                           |                                                         |                          |                                                                           |                                                         |                          |
| 1894.          |                                                                 |                                                                           |                                                         |                          |                                                                           |                                                         |                          |
| July, . . .    | 7,000                                                           | 2,500,000                                                                 | 13                                                      | 99.81                    | 4,900,000                                                                 | 23                                                      | 99.67                    |
| August, . . .  | 3,600                                                           | 2,520,000                                                                 | 19                                                      | 99.47                    | 4,980,000                                                                 | 17                                                      | 99.53                    |
| September, . . | 29,000                                                          | 2,520,000                                                                 | 2                                                       | 99.99                    | 5,020,000                                                                 | 4                                                       | 99.99                    |
| October, . . . | 36,000                                                          | 3,800,000                                                                 | 11                                                      | 99.98                    | 7,600,000                                                                 | 33                                                      | 99.94                    |
| 1895.          |                                                                 |                                                                           |                                                         |                          |                                                                           |                                                         |                          |
| May, . . .     | 7,700                                                           | 4,480,000                                                                 | 102                                                     | 98.68                    | 9,980,000                                                                 | 96                                                      | 96.75                    |
| June, . . .    | 18,000                                                          | 5,140,000                                                                 | 111                                                     | 99.31                    | 10,060,000                                                                | 95                                                      | 99.48                    |
| July, . . .    | 13,000                                                          | 4,940,000                                                                 | 89                                                      | 99.32                    | 9,580,000                                                                 | 17                                                      | 99.67                    |
| August, . . .  | 7,700                                                           | 4,900,000                                                                 | 60                                                      | 99.23                    | 9,580,000                                                                 | 56                                                      | 99.28                    |
| September, . . | 10,000                                                          | 4,880,000                                                                 | 65                                                      | 99.35                    | 9,740,000                                                                 | 68                                                      | 99.32                    |
| October, . . . | 52,000                                                          | 5,060,000                                                                 | 65                                                      | 99.88                    | 9,840,000                                                                 | 533                                                     | 98.98                    |
| November, . .  | 6,800                                                           | 4,760,000                                                                 | 73                                                      | 98.93                    | 7,280,000                                                                 | 42                                                      | 99.39                    |

Nearly all of the filters have been operated during 1895 at rates which would have formerly been considered abnormally high, but the good and uniform bacterial efficiency obtained at these high rates of filtration certainly go to prove that, in estimates of the cost of construction of natural sand filter beds, rates of filtration equal to four or five million gallons per acre daily can be considered safe with water of about the character of that of the Merrimack River.

*The Effect of the Method of Application of Water to the Filters upon Bacterial Efficiency.*

There have been in operation at the station during 1895 fourteen continuous and five intermittent water filters. To all of these filters Merrimack River water, containing a large percentage of dissolved oxygen, has been applied, and none of the filters which have contained more than 12 inches in depth of filtering material and were in operation during 1894 have given a bacterial efficiency of less than 98.74 per cent. The method of operating the intermittent filters was the same as during 1894, and as follows: at 6.30 A.M. the application of water was stopped and the filter allowed to drain for two hours from the time when the surface was first uncovered; water was then again applied and the gate of the outlet pipe kept constantly open. Operating in this way, the air drawn into the filter while the surface was uncovered and the filter was draining was largely forced downward through the outlet and much surface disturbance prevented. Taking intermittent Filter No. 3 B and its continuous mate, Filter No. 8 A, both of which were operated throughout the entire year, we find that Filter No. 8 A has given the greatest bacterial efficiency. Upon a comparison of their efficiency during different seasons of the year it is found that during weather when the temperature of the day is not, or but slightly, below the freezing point, Filter No. 3 B has given an efficiency nearly or quite equal to Filter No. 8 A. During freezing weather, however, the exposure of the surface of Filter No. 3 B has resulted in decreased efficiency at times.



*Table showing Comparative Bacterial Efficiency of Intermittent and Continuous Filters at Different Seasons of the Year.*

| 1895.<br>WEEK ENDING — | The<br>Applied<br>Water. | BACTERIA PER CUBIC CENTIMETER IN —          |        |        |        |                                           |         |        |        |
|------------------------|--------------------------|---------------------------------------------|--------|--------|--------|-------------------------------------------|---------|--------|--------|
|                        |                          | EFFLUENT OF INTERMITTENT<br>FILTER NO. 3 B. |        |        |        | EFFLUENT OF CONTINUOUS<br>FILTER NO. 8 A. |         |        |        |
|                        |                          | 5 A.M.                                      | 9 A.M. | 1 P.M. | 5 P.M. | 5 A.M.                                    | 11 A.M. | 1 P.M. | 5 P.M. |
| January 5, . . .       | 16,400                   | 24                                          | —      | 34     | 35     | 15                                        | 15      | 19     | 17     |
| 12, . . .              | 20,400                   | 139                                         | —      | 150    | 314    | 30                                        | 28      | 27     | 35     |
| 19, . . .              | 18,500                   | 84                                          | —      | 99     | 100    | 30                                        | 37      | 37     | 61     |
| 26, . . .              | 14,800                   | 163                                         | —      | 113    | 174    | 38                                        | 28      | —      | 23     |
| February 2, . . .      | 15,300                   | 235                                         | —      | 168    | 158    | 85                                        | 24      | —      | 44     |
| August 3, . . .        | 10,700                   | 15                                          | 23     | 25     | 20     | 24                                        | 15      | 15     | 13     |
| 10, . . .              | 11,000                   | 24                                          | 18     | 14     | 14     | 26                                        | 44      | 29     | 20     |
| 17, . . .              | 5,700                    | 12                                          | 12     | 14     | 18     | 19                                        | 14      | 11     | 14     |
| 24, . . .              | 6,600                    | 9                                           | 10     | 13     | 10     | 16                                        | 13      | 13     | 19     |
| December 7, . . .      | 8,000                    | 7                                           | 5      | 9      | 9      | 7                                         | 6       | 6      | 6      |
| 14, . . .              | 7,000                    | 11                                          | 8      | 11     | 7      | 5                                         | 6       | 6      | 5      |
| 21, . . .              | 5,800                    | 19                                          | 16     | 16     | 20     | 17                                        | 16      | 8      | 6      |

*Method of Putting Filters into Operation after Scraping.*

It has been the custom during the year, with the large out-door filters Nos. 3 B, 7 A and 8 A, after scraping to remove clogging, to rake the surface of the filter to a depth of 1 inch and then fill the filter slowly from below with city filtered water. The filters have then been allowed to rest for a number of hours with their surface covered with water before starting filtering again. The small iron filters, after scraping to remove clogging, have been started without raking and with canal water applied from above. The better bacterial results are obtained by the first treatment. Of the thirteen scrapings of Filter No. 3 B, ten had no appreciable effect upon the number of bacteria in the effluent, and of the seventeen scrapings of Filter No. 8 A, sixteen had no appreciable effect upon the number of bacteria in the effluent.

On Oct. 28, 1894, Filter No. 3 B was spaded over to a depth of about 6 inches for experimental purposes, and the bacterial results following this treatment are given in a table in the report of the Board for 1894, which is here repeated. The filter, after this spading over, was started by applying canal water from above.

*Bacteria per Cubic Centimeter in Effluent of Filter No. 3 B.*

| 1894.              | Hour.      | Bacteria. | Remarks.                                                                                                      |
|--------------------|------------|-----------|---------------------------------------------------------------------------------------------------------------|
| November 28, . . . | 8.00 A.M.  | 150       | Before spading.<br>Spading completed and water applied from the top at 10.50 A.M. Outlet gate was not closed. |
| 28, . . .          | 12.30 P.M. | 1,690     |                                                                                                               |
| 28, . . .          | 2.00 P.M.  | 2,598     |                                                                                                               |
| 28, . . .          | 3.00 P.M.  | 980       |                                                                                                               |
| 28, . . .          | 4.00 P.M.  | 1,260     |                                                                                                               |
| 28, . . .          | 6.00 P.M.  | 1,120     |                                                                                                               |
| 30, . . .          | -          | 1,300     | This and remaining numbers are averages of four analyses.                                                     |
| December 1, . . .  | -          | 735       |                                                                                                               |
| 2, . . .           | -          | -         |                                                                                                               |
| 3, . . .           | -          | 508       |                                                                                                               |
| 4, . . .           | -          | 346       | Surface clogged again.                                                                                        |
| 5, . . .           | -          | 339       |                                                                                                               |

The average number of bacteria in the applied river water during this period was about 12,000 per cubic centimeter.

On Oct. 23, 1895, Filter No. 3 B, while operating at the same rate as in November, 1894, was again spaded over to a depth of 6 inches, but was put in operation after this treatment by filling it slowly from below with city filtered water and then allowing it to stand with its surface covered with water for two hours before again turning on the river water and opening the outlet gate. The bacterial results subsequent to this treatment are given in the following table:—

*Bacteria per Cubic Centimeter in Effluent of Filter No. 3 B.*

| 1895.                 | Hour.      | Bacteria. | Remarks.                                                              |
|-----------------------|------------|-----------|-----------------------------------------------------------------------|
| October 23, . . . . . | 8.30 A.M.  | 10        | Before spading.<br>Outlet gate just opened after spading and filling. |
| 24, . . . . .         | 8.15 A.M.  | 24        |                                                                       |
| 24, . . . . .         | 9.00 A.M.  | 48        |                                                                       |
| 24, . . . . .         | 10.00 A.M. | 67        |                                                                       |
| 24, . . . . .         | 10.30 A.M. | 16        |                                                                       |
| 24, . . . . .         | 10.40 A.M. | 43        |                                                                       |
| 24, . . . . .         | 10.50 A.M. | 21        |                                                                       |
| 24, . . . . .         | 11.00 A.M. | 32        |                                                                       |
| 24, . . . . .         | 11.45 A.M. | 34        |                                                                       |
| 24, . . . . .         | 1.00 P.M.  | 27        |                                                                       |
| 24, . . . . .         | 2.00 P.M.  | 30        |                                                                       |
| 24, . . . . .         | 3.00 P.M.  | 38        |                                                                       |
| 24, . . . . .         | 5.00 P.M.  | 35        |                                                                       |
| 24, . . . . .         | 7.00 P.M.  | 35        |                                                                       |
| 25, . . . . .         | -          | 54        |                                                                       |
| 26, . . . . .         | -          | 25        |                                                                       |
| 28, . . . . .         | -          | 19        |                                                                       |
| 29, . . . . .         | -          | 16        |                                                                       |
| 30, . . . . .         | -          | 9         |                                                                       |
| 31, . . . . .         | -          | 15        |                                                                       |

Bacteria in the applied water during this period averaged 3,000 per cubic centimeter.

*Summary of Results of Scraping Water Filters.*

The following table summarizes the results obtained during the year in regard to the volume of water filtered between scrapings, and the approximate depths of sand removed at each scraping, for all filters whose depth remained practically the same throughout their period of operation.

*Summary of Results of Scraping Water Filters during 1895.*

| NUMBER OF FILTER. | Effective Size of Sand. (Millimeters.) | Approximate Depth of Sand. (Inches.) | Maximum Loss of Head. (Inches.) | Rate. (Gallons per Acre Daily.) | Method of Operation. | Average Depth of Sand removed at Each Scraping. (Inches.) | Average Quantity of Water filtered between Scrapings. (Gallons per Acre.) |
|-------------------|----------------------------------------|--------------------------------------|---------------------------------|---------------------------------|----------------------|-----------------------------------------------------------|---------------------------------------------------------------------------|
| 3 B, . . .        | 0.23                                   | 60                                   | 70                              | 3,096,000                       | Intermittent         | .60                                                       | 103,000,000                                                               |
| 7 A, . . .        | 0.26                                   | 24                                   | 65                              | 3,759,000                       | Continuous.          | .59                                                       | 75,000,000                                                                |
| 8 A, . . .        | 0.23                                   | 60                                   | 70                              | 3,576,000                       | Continuous.          | .60                                                       | 71,000,000                                                                |
| 23 A, . . .       | 0.14                                   | 55                                   | 70                              | 1,980,000                       | Continuous.          | .30                                                       | 40,000,000                                                                |
| 41, . . .         | 0.14                                   | 55                                   | 70                              | 1,980,000                       | Intermittent.        | .37                                                       | 34,000,000                                                                |
| 43, . . .         | 0.38                                   | 55                                   | 70                              | 4,280,000                       | Continuous.          | .43                                                       | 90,000,000                                                                |
| 49, . . .         | 0.38                                   | 55                                   | 70                              | 3,200,000                       | Continuous.          | .45                                                       | 72,000,000                                                                |

**CHEMICAL PURIFICATION BY FILTRATION.**

All of the suspended organic matter in the applied river water is removed by filtration and a large but variable amount of the soluble organic and coloring matters. During 1894 the average removal of color was 43 per cent., of albuminoid ammonia 55 per cent., and of oxygen consumed 44 per cent. of that in the unfiltered Merrimack River water. These results were better than those obtained during 1893 and also better than the results obtained during 1895, as shown by the following table. A summary of this table shows that the filters have removed during 1895, 30 per cent. of the color, 52 per cent. of the albuminoid ammonia and 26 per cent. of the oxygen consumed in the applied river water. The better results obtained upon the removal of color and oxygen consumed during 1894 were probably due to the fact that at the beginning of 1894 the filters were filled to their original height with new sand, and the experience of the station has been that most varieties of sands have the greatest efficiency in regard to the removal of color during the beginning of their period of use for filtration. The removal of albuminoid ammonia was practically the same as during 1894. The results for these two years indicate that old filters are as efficient as new in removing that organic matter determined as albuminoid ammonia. With the applied Merrimack River water, always containing a considerable percentage of dissolved oxygen, there was practically no difference during the year between the results obtained by intermittent as compared with continuous filtration, and dissolved oxygen has invariably been present in the effluents of the various filters, with the exception of the effluent of Filter No. 48, during a portion of September. This filter was operating at this time at a rate of 10,000,000 gallons per acre daily.

Table showing Percentages which the Color, Albuminoid Ammonia, and Oxygen consumed in the Effluents were of those in the Applied Water.

| NUMBER OF FILTER. | MAY.   |        |                     |                  | JUNE.  |        |                     |                  | JULY.  |        |                     |                  | AUGUST. |        |                     |                  | SEPTEMBER. |        |                     |                  | OCTOBER. |        |                     |                  | NOVEMBER. |        |                     |                  |
|-------------------|--------|--------|---------------------|------------------|--------|--------|---------------------|------------------|--------|--------|---------------------|------------------|---------|--------|---------------------|------------------|------------|--------|---------------------|------------------|----------|--------|---------------------|------------------|-----------|--------|---------------------|------------------|
|                   | Rate.* | Color. | Albuminoid Ammonia. | Oxygen Consumed. | Rate.* | Color. | Albuminoid Ammonia. | Oxygen Consumed. | Rate.* | Color. | Albuminoid Ammonia. | Oxygen Consumed. | Rate.*  | Color. | Albuminoid Ammonia. | Oxygen Consumed. | Rate.*     | Color. | Albuminoid Ammonia. | Oxygen Consumed. | Rate.*   | Color. | Albuminoid Ammonia. | Oxygen Consumed. | Rate.*    | Color. | Albuminoid Ammonia. | Oxygen Consumed. |
| 3B,†              | 4.3    | 70     | 49                  | 75               | 3.7    | 60     | 35                  | 67               | 3.8    | 54     | 40                  | 60               | 3.8     | 50     | 33                  | 33               | 3.9        | 47     | 35                  | 55               | 3.6      | 78     | 55                  | 85               | 2.8       | 70     | 46                  | 72               |
| 7A,†              | 4.6    | 75     | 58                  | 77               | 3.9    | 74     | 43                  | 74               | 4.5    | 57     | 43                  | 64               | 4.4     | 63     | 39                  | 64               | 4.1        | 62     | 41                  | 66               | 4.4      | 65     | 53                  | 76               | 4.3       | 72     | 51                  | 83               |
| 8A,†              | 4.5    | 70     | 43                  | 73               | 4.2    | 67     | 30                  | 64               | 4.7    | 57     | 35                  | 63               | 4.4     | 53     | 38                  | 56               | 4.3        | 60     | 40                  | 62               | 4.6      | 66     | 51                  | 75               | 4.0       | 70     | 46                  | 72               |
| 18A,†             | 5.0    | 82     | 54                  | 77               | 4.4    | 68     | 46                  | 82               | 4.3    | 61     | 39                  | 62               | 4.3     | 53     | 44                  | 58               | 4.7        | 56     | 45                  | 66               | 4.9      | 62     | 51                  | 65               | 4.7       | 97     | 72                  | 98               |
| 33A,†             | 2.0    | 80     | 57                  | 73               | 1.9    | 59     | 43                  | 73               | 1.9    | 61     | 34                  | 62               | 2.0     | 56     | 39                  | 46               | 1.9        | 56     | 38                  | 62               | 1.9      | 54     | 40                  | 56               | 2.0       | 92     | 55                  | 86               |
| 38A,†             | 1.0    | 80     | 54                  | 77               | 1.0    | 68     | 41                  | 82               | 1.0    | 61     | 35                  | 62               | 1.0     | 56     | 47                  | 64               | 1.0        | 56     | 38                  | 62               | 1.9      | 54     | 40                  | 56               | 2.0       | 92     | 55                  | 86               |
| 41,†              | 2.3    | 80     | 49                  | 73               | 2.3    | 52     | 34                  | 64               | 1.9    | 56     | 31                  | 53               | 1.9     | 56     | 30                  | 56               | 1.9        | 56     | 30                  | 56               | 1.9      | 56     | 30                  | 56               | 1.9       | 56     | 30                  | 56               |
| 42,†              | 4.8    | 89     | 60                  | 86               | 4.2    | 83     | 45                  | 85               | 4.7    | 71     | 46                  | 76               | 4.9     | 65     | 38                  | 69               | 4.7        | 56     | 50                  | 66               | 4.8      | 61     | 48                  | 65               | 4.7       | 102    | 57                  | 91               |
| 43,†              | 5.0    | 91     | 57                  | 82               | 4.8    | 73     | 45                  | 85               | 4.4    | 71     | 46                  | 76               | 4.9     | 65     | 38                  | 69               | 4.7        | 56     | 50                  | 66               | 4.8      | 61     | 48                  | 65               | 4.7       | 102    | 57                  | 91               |
| 44,†              | 6.8    | 100    | 56                  | 84               | 6.9    | 68     | 41                  | 82               | 7.0    | 66     | 40                  | 69               | 7.2     | 68     | 48                  | 67               | 4.6        | 56     | 43                  | 62               | 4.0      | 61     | 48                  | 63               | 3.8       | 95     | 55                  | 89               |
| 45,†              | 4.8    | 86     | 54                  | 77               | 4.5    | 68     | 37                  | 79               | 4.3    | 66     | 40                  | 67               | 4.8     | 62     | 52                  | 67               | 4.6        | 56     | 43                  | 62               | 4.0      | 61     | 48                  | 63               | 3.8       | 95     | 55                  | 89               |
| 46,†              | 5.1    | 91     | 57                  | 98               | 4.6    | 73     | 45                  | 90               | 4.7    | 71     | 41                  | 76               | 4.6     | 65     | 59                  | 69               | 4.5        | 56     | 43                  | 68               | 4.9      | 59     | 45                  | 65               | 4.8       | 85     | 56                  | 98               |
| 47,†              | 7.0    | 93     | 58                  | 89               | 6.2    | 73     | 18                  | 87               | 6.3    | 66     | 41                  | 67               | 6.8     | 68     | 57                  | 69               | 4.5        | 56     | 43                  | 68               | 4.9      | 59     | 45                  | 65               | 4.8       | 85     | 56                  | 98               |
| 48,†              | 4.4    | 70     | 45                  | 57               | 4.8    | 57     | 37                  | 72               | 4.8    | 73     | 44                  | 71               | 4.8     | 65     | 48                  | 72               | 9.1        | 56     | 47                  | 69               | 9.5      | 89     | 50                  | 65               | 7.3       | 90     | 68                  | 94               |
| 49,†              | 10.0   | 68     | 46                  | 59               | 9.4    | 57     | 39                  | 72               | 9.3    | 70     | 45                  | 74               | 9.3     | 65     | 48                  | 72               | 9.1        | 56     | 47                  | 69               | 9.5      | 89     | 50                  | 65               | 7.3       | 90     | 68                  | 94               |
| 50,†              | 4.6    | 91     | 58                  | 80               | 4.7    | 68     | 42                  | 85               | 4.8    | 66     | 44                  | 69               | 4.9     | 65     | 45                  | 72               | 4.7        | 53     | 43                  | 62               | 5.0      | 65     | 44                  | 66               | 4.9       | 97     | 63                  | 91               |
| 62,†              | 4.6    | 91     | 58                  | 80               | 4.7    | 68     | 42                  | 85               | 4.8    | 66     | 44                  | 69               | 4.9     | 65     | 45                  | 72               | 4.7        | 53     | 43                  | 62               | 5.0      | 65     | 44                  | 66               | 4.9       | 97     | 63                  | 91               |
| 63,†              | 4.6    | 91     | 58                  | 80               | 4.7    | 68     | 42                  | 85               | 4.8    | 66     | 44                  | 69               | 4.9     | 65     | 45                  | 72               | 4.7        | 53     | 43                  | 62               | 5.0      | 65     | 44                  | 66               | 4.9       | 97     | 63                  | 91               |
| 64,†              | 4.6    | 91     | 58                  | 80               | 4.7    | 68     | 42                  | 85               | 4.8    | 66     | 44                  | 69               | 4.9     | 65     | 45                  | 72               | 4.7        | 53     | 43                  | 62               | 5.0      | 65     | 44                  | 66               | 4.9       | 97     | 63                  | 91               |

\* Million gallons per acre daily.

† Intermittent filters.

*Table showing Per Cent. which Oxygen dissolved in the Applied Water and Effluents was of that necessary for Saturation at Actual Temperature.*

| MONTH.               | Canal<br>Water. | IN EFFLUENTS OF FILTERS NOS. — |      |      |        |       |     |      |     |     |     |      |     |      |     |     |     |     |     |     |
|----------------------|-----------------|--------------------------------|------|------|--------|-------|-----|------|-----|-----|-----|------|-----|------|-----|-----|-----|-----|-----|-----|
|                      |                 | 3 B.*                          | 7 A. | 8 A. | 18 A.* | 33 A. | 38. | 41.* | 42. | 43. | 44. | 45.* | 46. | 47.* | 48. | 49. | 50. | 62. | 63. | 64. |
| 1895.                |                 |                                |      |      |        |       |     |      |     |     |     |      |     |      |     |     |     |     |     |     |
| January, . . . . .   | 83              | 75                             | —    | 70   | —      | —     | —   | —    | —   | —   | —   | —    | —   | —    | —   | —   | —   | —   | —   | —   |
| February, . . . . .  | 82              | 81                             | —    | 53   | —      | —     | —   | —    | —   | —   | —   | —    | —   | —    | —   | —   | —   | —   | —   | —   |
| March, . . . . .     | 79              | 82                             | —    | 76   | —      | —     | —   | —    | —   | —   | —   | —    | —   | —    | —   | —   | —   | —   | —   | —   |
| April, . . . . .     | 98              | 86                             | 86   | 81   | —      | —     | —   | —    | —   | —   | —   | —    | —   | —    | —   | —   | —   | —   | —   | —   |
| May, . . . . .       | 88              | 73                             | 74   | 55   | 59     | 38    | 55  | 81   | 61  | 39  | 43  | —    | 63  | 70   | 71  | 81  | 55  | —   | —   | —   |
| June, . . . . .      | 92              | 57                             | 24   | 41   | 48     | 6     | 8   | 58   | 38  | 15  | 14  | 58   | 24  | 54   | 44  | 46  | 35  | —   | —   | —   |
| July, . . . . .      | 59              | 58                             | 25   | 21   | 48     | 19    | 11  | 60   | 35  | 6   | 27  | 47   | 26  | 48   | 22  | 22  | 25  | —   | —   | —   |
| August, . . . . .    | 55              | 69                             | 45   | 19   | 52     | 5     | 6   | 58   | 15  | 11  | 10  | 32   | 4   | 19   | 4   | 5   | 5   | —   | —   | —   |
| September, . . . . . | 50              | 71                             | 40   | 25   | 13     | 1     | —   | —    | 16  | 5   | —   | 39   | —   | —    | 1   | 0   | 14  | 20  | 14  | 28  |
| October, . . . . .   | 68              | 74                             | 30   | 31   | 56     | 29    | —   | —    | 42  | 25  | —   | 57   | —   | —    | 20  | 20  | 23  | 29  | 27  | 32  |
| November, . . . . .  | 99              | 97                             | 85   | 81   | 95     | 73    | —   | —    | 95  | 82  | —   | —    | —   | —    | 91  | 84  | 84  | 82  | 83  | 87  |
| Averages, . . . . .  | 75              | 75                             | 53   | 53   | 53     | 25    | 20  | 64   | 43  | 26  | 24  | 47   | 29  | 48   | 36  | 37  | 38  | 44  | 41  | 49  |

• Intermittent.

*The Water taken from the Merrimack River and applied to the  
Experimental Filters.*

All the water applied to the filters during 1895 has been Merrimack River water, taken from the Essex Company's canal. During a large part of the year an abundant supply was obtained through a 12-inch iron pipe connected with the locks at the foot of the canal. This pipe is above the ground and cannot be used during winter weather, and for this reason our supply of water is more limited during cold weather, when we are dependent upon the water obtained through a 4-inch pipe from the same canal.

The results of the analyses of the water as it flows upon the filters at the station are given in the next two tables; the first giving the average daily results of two or more bacterial determinations and the second giving the monthly averages of the chemical analyses. With the latter table are given the results of bacterial analyses of samples taken at the same time that the samples for chemical analysis were taken. Their average is of course not identical with the average results of the preceding table.

Average of Daily (8 A.M. and 4 P.M.) Number of Bacteria per Cubic Centimeter in Canal Water, 1895.

| DAY OF MONTH. |   |   |   |   |   |   |   |   |   | January. | February. | March. | April. | May.   | June.  | July.  | August. | September. | October. | November. | December. |
|---------------|---|---|---|---|---|---|---|---|---|----------|-----------|--------|--------|--------|--------|--------|---------|------------|----------|-----------|-----------|
| 1,            | . | . | . | . | . | . | . | . | . | 17,600   | 13,000    | 19,000 | 11,000 | 4,000  | 8,000  | 11,000 | 16,000  | -          | 3,500    | 5,000     | -         |
| 2,            | . | . | . | . | . | . | . | . | . | 15,400   | 12,000    | 19,000 | 9,000  | 4,000  | -      | 11,000 | 13,000  | 3,500      | 66,000   | 4,200     | 8,500     |
| 3,            | . | . | . | . | . | . | . | . | . | 17,000   | -         | -      | 9,000  | 3,000  | 5,500  | 14,000 | 8,000   | 4,000      | 319,000  | -         | 4,100     |
| 4,            | . | . | . | . | . | . | . | . | . | 16,000   | 15,000    | 33,000 | 9,000  | 3,000  | 25,000 | 20,000 | -       | 6,000      | 110,000  | 8,300     | 5,900     |
| 5,            | . | . | . | . | . | . | . | . | . | 15,000   | 14,000    | 21,000 | 12,000 | -      | 20,000 | 13,000 | 18,000  | 13,000     | 46,000   | 3,400     | 9,100     |
| 6,            | . | . | . | . | . | . | . | . | . | -        | 18,000    | 17,000 | 9,000  | 2,000  | 23,000 | 12,000 | 7,500   | 7,500      | -        | 4,200     | 8,700     |
| 7,            | . | . | . | . | . | . | . | . | . | 19,000   | 18,000    | 17,000 | 11,000 | 4,000  | 12,000 | 9,000  | 14,000  | 5,000      | 20,000   | 7,200     | 11,700    |
| 8,            | . | . | . | . | . | . | . | . | . | 26,000   | 27,000    | 18,000 | 5,000  | 4,500  | 11,000 | 10,000 | 10,000  | 3,500      | 126,000  | 4,600     | -         |
| 9,            | . | . | . | . | . | . | . | . | . | 22,000   | 18,000    | 34,000 | 9,000  | 3,000  | -      | 6,500  | 10,000  | 3,500      | 25,000   | 5,800     | 14,400    |
| 10,           | . | . | . | . | . | . | . | . | . | 17,000   | -         | -      | 12,000 | 8,000  | 8,000  | 14,000 | 6,500   | 4,000      | 298,000  | 4,000     | 4,500     |
| 11,           | . | . | . | . | . | . | . | . | . | 13,000   | 19,000    | 16,000 | -      | 4,500  | 24,000 | 21,000 | -       | 5,500      | 96,000   | 4,000     | 5,000     |
| 12,           | . | . | . | . | . | . | . | . | . | 22,000   | 17,000    | 16,000 | -      | -      | 40,000 | 15,000 | 4,000   | 4,000      | 147,000  | 4,500     | 4,000     |
| 13,           | . | . | . | . | . | . | . | . | . | -        | 17,000    | 12,000 | -      | 9,000  | 38,000 | 24,000 | 4,000   | 4,000      | -        | 3,900     | 7,800     |
| 14,           | . | . | . | . | . | . | . | . | . | 27,000   | 17,000    | 12,000 | -      | 8,000  | 35,000 | 13,000 | 12,000  | 4,000      | 18,000   | 4,800     | 5,500     |
| 15,           | . | . | . | . | . | . | . | . | . | 16,000   | 16,000    | 18,000 | -      | 6,000  | -      | 13,000 | 7,000   | 12,000     | 17,000   | 4,000     | -         |
| 16,           | . | . | . | . | . | . | . | . | . | 19,000   | 12,000    | 15,000 | -      | 4,500  | 12,000 | 35,000 | 3,000   | 3,000      | 9,000    | 6,400     | -         |
| 17,           | . | . | . | . | . | . | . | . | . | 14,000   | -         | -      | -      | 11,000 | 7,500  | 22,000 | -       | 22,000     | 11,000   | -         | 7,600     |
| 18,           | . | . | . | . | . | . | . | . | . | 16,000   | 16,000    | 18,000 | -      | -      | 25,000 | 13,000 | 4,000   | 22,000     | 7,000    | 10,000    | 5,400     |
| 19,           | . | . | . | . | . | . | . | . | . | 19,000   | 14,000    | 20,000 | -      | 6,500  | 23,000 | 10,000 | 4,000   | 34,000     | 6,500    | 7,800     | 8,900     |
| 20,           | . | . | . | . | . | . | . | . | . | -        | 15,000    | 13,000 | -      | 5,500  | 27,000 | 10,000 | 4,000   | 29,000     | 6,000    | 4,900     | -         |
| 21,           | . | . | . | . | . | . | . | . | . | 18,000   | 17,000    | 11,000 | -      | 6,000  | 27,000 | -      | 10,000  | 34,000     | 4,500    | 12,000    | 5,900     |
| 22,           | . | . | . | . | . | . | . | . | . | 12,000   | 11,000    | 11,000 | -      | 6,000  | 22,000 | 5,500  | 7,000   | 6,000      | 2,000    | 8,400     | -         |
| 23,           | . | . | . | . | . | . | . | . | . | 15,000   | 10,000    | 12,000 | -      | 5,000  | -      | 7,000  | 7,500   | 6,000      | 1,300    | 6,000     | 9,500     |
| 24,           | . | . | . | . | . | . | . | . | . | 14,000   | -         | -      | -      | 3,500  | 12,000 | 8,500  | 7,000   | 3,400      | 3,400    | -         | 12,000    |
| 25,           | . | . | . | . | . | . | . | . | . | 13,000   | 14,000    | 21,000 | -      | 4,000  | -      | 11,000 | -       | 16,000     | 5,000    | 5,100     | -         |
| 26,           | . | . | . | . | . | . | . | . | . | 22,000   | 25,000    | 22,000 | -      | -      | 14,000 | 13,000 | 3,500   | 11,000     | 2,900    | 5,500     | 8,800     |
| 27,           | . | . | . | . | . | . | . | . | . | 16,000   | 17,000    | 27,000 | -      | 9,500  | 19,000 | 5,000  | 8,500   | 13,000     | 16,000   | 13,700    | -         |
| 28,           | . | . | . | . | . | . | . | . | . | 24,000   | 16,000    | 39,000 | -      | 10,000 | 19,000 | 4,000  | 5,000   | 7,500      | -        | 17,500    | -         |
| 29,           | . | . | . | . | . | . | . | . | . | 15,000   | -         | 12,000 | -      | 14,000 | 22,000 | 8,000  | 7,000   | -          | 2,300    | 8,300     | -         |
| 30,           | . | . | . | . | . | . | . | . | . | 13,000   | -         | 13,000 | -      | 13,000 | -      | 15,000 | 5,000   | 2,500      | 4,200    | 14,500    | 13,300    |
| 31,           | . | . | . | . | . | . | . | . | . | 15,000   | -         | -      | -      | 9,000  | -      | 15,000 | 5,500   | -          | 2,700    | -         | 5,500     |

*Monthly Averages of Analyses of Canal Water (Merrimack River).*

[Parts per 100,000.]

| DATE — 1895.     | Tempera-<br>ture.<br><br>Deg. F. | Color. | AMMONIA. |             |          | Chlorine. | NITROGEN<br>AS |           | Oxygen<br>Consumed. | Per Cent. of Dis-<br>solved Oxygen. | Bacteria per Cubic<br>Centimeter. |
|------------------|----------------------------------|--------|----------|-------------|----------|-----------|----------------|-----------|---------------------|-------------------------------------|-----------------------------------|
|                  |                                  |        | Free.    | ALBUMINOID. |          |           | Nitrates.      | Nitrites. |                     |                                     |                                   |
|                  |                                  |        |          | Total.      | Soluble. |           |                |           |                     |                                     |                                   |
| January, . . .   | 34                               | .35    | .0122    | .0194       | .0153    | .30       | .0200          | .0001     | .89                 | 102                                 | 17,000                            |
| February, . . .  | 32                               | .35    | .0131    | .0202       | .0172    | .33       | .0190          | .0000     | .49                 | 82                                  | 20,000                            |
| March, . . .     | 36                               | .43    | .0161    | .0334       | .0268    | .26       | .0230          | .0002     | .52                 | 102                                 | 17,000                            |
| April, . . .     | 39                               | .54    | .0029    | .0167       | .0149    | .19       | .0170          | .0000     | .51                 | 100                                 | 12,000                            |
| May, . . .       | 61                               | .44    | .0045    | .0168       | .0147    | .16       | .0180          | .0002     | .44                 | 80                                  | 5,000                             |
| June, . . .      | 71                               | .44    | .0080    | .0210       | .0165    | .21       | .0110          | .0001     | .39                 | 55                                  | 23,000                            |
| July, . . .      | 72                               | .41    | .0085    | .0218       | .0179    | .27       | .0140          | .0004     | .42                 | 52                                  | 11,000                            |
| August, . . .    | 73                               | .34    | .0084    | .0198       | .0171    | .29       | .0110          | .0003     | .36                 | 48                                  | 7,000                             |
| September, . . . | 71                               | .34    | .0141    | .0206       | .0144    | .30       | .0190          | .0005     | .29                 | 44                                  | 7,000                             |
| October, . . .   | 51                               | .74    | .0082    | .0287       | .0231    | .21       | .0150          | .0003     | .80                 | 68                                  | 9,000                             |
| November, . . .  | 44                               | .61    | .0040    | .0239       | .0190    | .19       | .0130          | .0002     | .64                 | 102                                 | 5,600                             |
| December, . . .  | 35                               | .48    | .0044    | .0158       | .0143    | .20       | .0180          | .0001     | .43                 | 99                                  | 5,300                             |

*Solids in the River Water during a Freshet.*

The following table records the solids in the water of the Merrimack River in April, 1895, during a period of severe freshet. The river water was very turbid, caused by a large amount of silt in suspension in it. The rapidity with which this silt settles is shown by the determinations of the solids, as given in the table, after the water had been allowed to stand in a gallon bottle for twenty-four hours, and also by allowing the water to stand in a 6-foot tube for different periods, as given in the table.

The total solids in the water on April 16 were 111 parts per 100,000 parts, and samples were taken from the river daily until April 25, when the water had returned to very nearly its normal condition.



*Solids in Merrimack River Water during the Freshet of April, 1895.*

| DATE OF SAMPLE. |                                                                                                                      | Portion of Sample Taken. | Time of Settling before Determination. | PARTS PER 100,000. |                   |               |
|-----------------|----------------------------------------------------------------------------------------------------------------------|--------------------------|----------------------------------------|--------------------|-------------------|---------------|
|                 |                                                                                                                      |                          |                                        | Total Solids.      | Loss on Ignition. | Fixed Solids. |
| April 16,       | { Sample stood twenty-four hours in a gallon bottle, and was then divided into three portions by means of a syphon.  | { Upper 3d.              | Hours. 24                              | 18.35              | 2.25              | 16.10         |
|                 |                                                                                                                      | { Middle 3d.             | 24                                     | 7.55               | 3.70              | 3.85          |
|                 |                                                                                                                      | { Lower 3d.              | 24                                     | 307.45             | 11.10             | 296.35        |
| 16,             | { Sample poured into a tube 6 feet high, 2½ inches diameter and allowed to settle. Portions syphoned off as desired. | { Upper foot.            | 6                                      | 8.80               | 1.30              | 7.50          |
|                 |                                                                                                                      | { Upper foot.            | 24                                     | 8.30               | 1.90              | 6.40          |
|                 |                                                                                                                      | { 3d foot.               | 6                                      | 9.80               | 2.20              | 7.60          |
|                 |                                                                                                                      | { 3d foot.               | 24                                     | 8.30               | 2.40              | 5.90          |
|                 |                                                                                                                      | { 5th foot.              | 6                                      | 10.40              | 3.70              | 7.70          |
|                 |                                                                                                                      | { 5th foot.              | 24                                     | 8.20               | 2.50              | 5.70          |
| 17,             | Determinations made immediately after sample was taken.                                                              | -                        | -                                      | 45.20              | 8.20              | 37.00         |
| 18,             | Determinations made immediately after sample was taken.                                                              | -                        | -                                      | 16.20              | 3.80              | 12.40         |
| 19,             | Determinations made immediately after sample was taken.                                                              | -                        | -                                      | 11.10              | 2.70              | 8.40          |
| 20,             | Determinations made immediately after sample was taken.                                                              | -                        | -                                      | 7.80               | 1.40              | 6.40          |
| 22,             | Determinations made immediately after sample was taken.                                                              | -                        | -                                      | 7.40               | 2.40              | 5.00          |
| 23,             | Determinations made immediately after sample was taken.                                                              | -                        | -                                      | 6.90               | 1.60              | 5.30          |
| 24,             | Determinations made immediately after sample was taken.                                                              | -                        | -                                      | 5.30               | 1.30              | 4.00          |
| 25,             | Determinations made immediately after sample was taken.                                                              | -                        | -                                      | 4.50               | 0.80              | 3.70          |

*Application of Bacillus Prodigiosus.*

*Bacillus prodigiosus* has been applied, together with the river water from the canal, to filters 3 B, 7 A, 8 A, 43, 44, 45, 48, 49, 62, 63 and 64 at different periods from March to November. The general plan of the experiments has been the same as in previous years (see annual report of the Board for 1892, page 529), except that the germ has been applied in smaller numbers. A pure culture of *B. prodigiosus* has been obtained by inoculation and growth for four days at 20° C. in a solution of one-tenth per cent. peptone and two-tenths per cent. glucose in city water. This mixture has been applied to the filters in the proportion of 1 part mixture to 170,000 parts of water, at intervals of one hour for ten hours a day and six days in a week.

Numerous examinations have been made at frequent intervals to determine whether or not this germ passed through the filters.

In order to strengthen the regular method of determination a number of tests were made (by using a large roll-tube) by which 50 cubic centimeters of effluent could be examined at a time. It is interesting to note that in no single instance in which the effluent

of Filter No. 8 A was examined by this method did a single *B. prodigiosus* appear.

In the next table are given the average numbers of *B. prodigiosus* per cubic centimeter in the applied water for ten hours during each day that this germ was applied to the filters.

*Average Number per Cubic Centimeter of Bacillus Prodigiosus in Applied River Water for Ten Hours Daily, 1895.*

| DAY OF MONTH. | March. | April. | May.  | June. | July. | Aug. | Sept. | Oct. | Nov. |
|---------------|--------|--------|-------|-------|-------|------|-------|------|------|
| 1, . . . . .  | 0      | 653    | 0     | 1,588 | 494   | 435  | 0     | 376  | 318  |
| 2, . . . . .  | 0      | 647    | 0     | 0     | 347   | 435  | 347   | 376  | 418  |
| 3, . . . . .  | 0      | 541    | 0     | 400   | 347   | 382  | 424   | 288  | 0    |
| 4, . . . . .  | 0      | 688    | 0     | 500   | 0     | 0    | 400   | 224  | 347  |
| 5, . . . . .  | 0      | 929    | 0     | 529   | 400   | 312  | 435   | 706  | 365  |
| 6, . . . . .  | 0      | 0      | 1,165 | 435   | 441   | 371  | 394   | 0    | 382  |
| 7, . . . . .  | 0      | 0      | 847   | 371   | 0     | 476  | 382   | 565  | 465  |
| 8, . . . . .  | 0      | 318    | 1,235 | 300   | 365   | 647  | 0     | 329  | 318  |
| 9, . . . . .  | 0      | 635    | 1,000 | 0     | 347   | 400  | 400   | 288  | 306  |
| 10, . . . . . | 0      | 224    | 553   | 235   | 359   | 335  | 471   | 229  | 0    |
| 11, . . . . . | 617    | 0      | 406   | 371   | 429   | 0    | 529   | 288  | 341  |
| 12, . . . . . | 500    | 182    | 0     | 418   | 376   | 476  | 706   | 359  | 341  |
| 13, . . . . . | 970    | 0      | 435   | 529   | 300   | 429  | 235   | 0    | 300  |
| 14, . . . . . | 1,882  | 0      | 500   | 806   | 0     | 382  | 471   | 347  | 318  |
| 15, . . . . . | 870    | 0      | 0     | 594   | 358   | 482  | 0     | 341  | 412  |
| 16, . . . . . | 247    | 0      | 400   | 0     | 465   | 435  | 206   | 459  | 0    |
| 17, . . . . . | 0      | 0      | 529   | 441   | 418   | 271  | 0     | 353  | 0    |
| 18, . . . . . | 400    | 0      | 0     | 400   | 429   | 0    | 371   | 294  | 535  |
| 19, . . . . . | 1,047  | 0      | 0     | 406   | 394   | 494  | 318   | 294  | 500  |
| 20, . . . . . | 618    | 0      | 553   | 424   | 294   | 488  | 0     | 0    | 418  |
| 21, . . . . . | 959    | 0      | 706   | 471   | 0     | 406  | 559   | 365  | 418  |
| 22, . . . . . | 1,470  | 0      | 765   | 282   | 400   | 435  | 0     | 312  | 429  |
| 23, . . . . . | 776    | 0      | 765   | 0     | 241   | 288  | 429   | 318  | 276  |
| 24, . . . . . | 0      | 0      | 0     | 635   | 500   | 400  | 341   | 300  | 0    |
| 25, . . . . . | 894    | 0      | 576   | 824   | 576   | 0    | 176   | 188  | 347  |
| 26, . . . . . | 1,000  | 0      | 0     | 588   | 524   | 659  | 282   | 312  | 294  |
| 27, . . . . . | 0      | 0      | 412   | 412   | 576   | 471  | 288   | 0    | 359  |
| 28, . . . . . | 0      | 0      | 382   | 347   | 0     | 359  | 359   | 441  | 0    |
| 29, . . . . . | 365    | 0      | 647   | 612   | 206   | 376  | 0     | 459  | 0    |
| 30, . . . . . | 882    | 0      | 253   | 0     | 635   | 441  | 271   | 465  | 0    |
| 31, . . . . . | 0      | -      | 1,353 | -     | 559   | 406  | -     | 412  | -    |

DETAILED ACCOUNT OF THE WORK OF THE SEVERAL WATER  
FILTERS IN 1895.

The remainder of this report upon water filtration contains a brief account of the construction and operation of each filter, the average results of daily bacterial analyses and the monthly averages of chemical analyses, together with the average bacterial results of samples taken at the same time the samples for chemical analyses were taken. The daily bacterial results are made up by averaging the results of several daily analyses in the case of filters Nos. 3 B, 7 A and 8 A.

All the in-door filters were, for reasons previously given, not operated from Dec. 1, 1894, until the spring of 1895, and all the filters were at times subjected to treatment not necessarily a part of filtration.

*Filter No. 3 B.*

This intermittent filter was started Sept. 23, 1893, and contained 60 inches in depth of sand of an effective size of 0.23 millimeter. The history of this filter up to Jan. 1, 1895, has been published in the annual reports of the Board. Its history during 1895 contained the following principal points.

In order to prevent the upper layers of sand from freezing during the period of intermittent operation, the gate in the canal water pipe was closed at 5 A.M. As a result of this procedure the surface of the sand became and remained uncovered for two hours during the warmest part of the day. From Dec. 29, 1894, to March 8, 1895, the prescribed rate of filtration was 1,500,000 gallons per acre daily. On March 11 this rate was increased to 5,000,000 gallons. The filter continued in operation at this rate until November 24, when the rate was decreased to 1,500,000 gallons per acre daily. On Sundays and on days following scrapings the filter ran continuously. As the water in the feed-pipe froze, the gate on the outlet was closed and the surface of the sand remained uncovered with water from February 6 to 13. High water in the river made it necessary to shut the valve again from April 11 to 13, and from April 14 to 19, though the surface of the sand was covered with water. The river silt was scraped from the surface April 20, and city water applied slowly from below on the 22d. After the surface became covered

the filter was allowed to stand full of water for forty-eight hours, and started at the usual rate April 28. On account of low water in the canal the gate on the outlet remained closed, and the surface of the sand covered with water on the following dates: March 10, 30, April 27, May 5, June 8, 16, 23, July 6, 13, 21, 25, August 3, September 22, 28 and November 23, for periods varying from twelve to thirty-six hours.

A short trap was attached to the outlet, but the lower foot of sand was not saturated. In order to remove clogging the filter was filled with city water from below on December 26, and the surface was raked to a depth of 1 inch on January 8. To remove clogging more efficiently the filter was scraped as follows: 1 inch of sand was removed on March 9 and 26;  $\frac{1}{2}$  inch (approximately) of sand was removed on June 25, July 31, August 26, October 1, 16, 23, November 7 and 18. After scraping, the filter was, on each occasion, raked to a depth of 1 inch, except on October 23, when it was spaded to a depth of 6 inches. On March 29 the filter was restored to its original height with new sand, after scraping. Before applying canal water the filter was filled with city (filtered) water slowly from below after scraping and allowed to stand for several hours.

A solution seeded with *Bacillus prodigiosus* was mixed with the applied canal water, in the ratio of 1 part to 170,000 parts, for ten hours a day, from March 11 to April 10, and from September 2 to November 21. Four samples of effluent collected at different hours each day (excepting Sunday) have been analyzed. Averages of these analyses, calculated for twenty-four-hour periods, are given in the following table:—

*Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter  
No. 3 B, 1895.*

| DAY.    | January. | February. | MARCH.          |                | April. | May. | June. | July. | August. | SEPTEMBER.      |                | October.        | November.      | December. |
|---------|----------|-----------|-----------------|----------------|--------|------|-------|-------|---------|-----------------|----------------|-----------------|----------------|-----------|
|         |          |           | Water Bacteria. | B. Prodigiosa. |        |      |       |       |         | Water Bacteria. | B. Prodigiosa. | Water Bacteria. | B. Prodigiosa. |           |
| 1, . .  | 42       | 71        | 104             | -              | 74     | 26   | 27    | 13    | -       | -               | -              | 8               | -              | -         |
| 2, . .  | 23       | 121       | 123             | -              | 89     | 53   | -     | 13    | 29      | 17              | 0              | 10              | -              | 11        |
| 3, . .  | 26       | -         | -               | -              | 63     | 34   | 26    | 24    | 18      | 7               | 0              | 233             | 1              | 4         |
| 4, . .  | 43       | 159       | 53              | -              | 74     | 24   | 26    | -     | -       | 14              | 0              | 90              | 0              | 3         |
| 5, . .  | 24       | 162       | 254             | -              | 53     | -    | 24    | 20    | 29      | 5               | 0              | 12              | 0              | 5         |
| 6, . .  | -        | -         | 445             | -              | 35     | 19   | 23    | 27    | 16      | 17              | 0              | -               | -              | 10        |
| 7, . .  | 47       | -         | 231             | -              | -      | 21   | 13    | -     | 13      | 5               | 0              | 37              | 0              | 12        |
| 8, . .  | 52       | -         | 49              | -              | 23     | 24   | 38    | 22    | 11      | -               | -              | 25              | 0              | -         |
| 9, . .  | 1,829    | -         | 255             | -              | 25     | 27   | -     | 33    | 6       | 9               | 0              | 13              | 0              | 3         |
| 10, . . | 599      | -         | -               | -              | 21     | 23   | 49    | 16    | 32      | 25              | 0              | 11              | 0              | 9         |
| 11, . . | 251      | -         | 1,143           | 5              | -      | 32   | 29    | 23    | -       | 7               | 0              | 13              | 1              | 20        |
| 12, . . | 140      | -         | 800             | 10             | -      | -    | 22    | 15    | 14      | 4               | 0              | 14              | 0              | 8         |
| 13, . . | -        | 746       | 1,097           | 5              | -      | 17   | 19    | 16    | 10      | 6               | 0              | -               | -              | 6         |
| 14, . . | 109      | 2,118     | 447             | 2              | -      | 24   | 37    | -     | 16      | 15              | 0              | 17              | 0              | 22        |
| 15, . . | 95       | 1,908     | 974             | 2              | -      | 44   | 25    | 23    | 12      | -               | -              | 4               | 0              | -         |
| 16, . . | 103      | 4,100     | 698             | 1              | -      | 22   | -     | 21    | 9       | 9               | 0              | 3               | 0              | 34        |
| 17, . . | 90       | -         | -               | -              | -      | 33   | 30    | 15    | 7       | 6               | 0              | 19              | 0              | 13        |
| 18, . . | 79       | 721       | 229             | 0              | -      | 26   | 34    | 16    | -       | 6               | 0              | 29              | 1              | 19        |
| 19, . . | 79       | 513       | 173             | 0              | -      | -    | 22    | 20    | 10      | 10              | 0              | 55              | 0              | 10        |
| 20, . . | -        | 440       | 261             | 0              | -      | 23   | 20    | 14    | 6       | 5               | 0              | -               | -              | 19        |
| 21, . . | 111      | 167       | 77              | 1              | -      | 19   | 27    | -     | 8       | 4               | 0              | 14              | 0              | 15        |
| 22, . . | 146      | 406       | 76              | 0              | -      | 130  | 11    | 26    | 10      | -               | -              | 18              | 0              | -         |
| 23, . . | 80       | 157       | 85              | 0              | -      | 36   | -     | 15    | 8       | 16              | 0              | 6               | 0              | 7         |
| 24, . . | 82       | -         | -               | 0              | -      | 109  | 35    | 14    | 15      | 8               | 0              | 36              | -              | 6         |
| 25, . . | 225      | 72        | 28              | -              | 58     | 43   | 43    | 30    | -       | 13              | 0              | 54              | -              | -         |
| 26, . . | 358      | 40        | 28              | -              | 43     | -    | 29    | 25    | 14      | 8               | 0              | 24              | 1              | 5         |
| 27, . . | -        | 451       | -               | -              | 43     | 55   | 35    | 21    | 46      | 16              | 0              | -               | -              | 11        |
| 28, . . | 438      | 247       | 304             | -              | -      | 77   | 35    | -     | 25      | 10              | 0              | 19              | -              | 16        |
| 29, . . | 243      | -         | 168             | -              | 62     | 54   | 24    | 20    | 19      | -               | -              | 16              | -              | -         |
| 30, . . | 143      | -         | 158             | -              | 33     | 36   | -     | 12    | 15      | 20              | 0              | 9               | -              | 14        |
| 31, . . | 132      | -         | -               | -              | 25     | 39   | -     | 16    | 7       | -               | -              | 15              | -              | 9         |

*Monthly Averages of Analyses of Effluent of Filter No. 3 B.*

[Parts per 100,000.]

| 1895.          | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | Bacteria per Cubic Centimeter. |
|----------------|--------------------------------------------------|-------------------------|-----------|--------|----------|---------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|
|                |                                                  | Applied Water.          | Effluent. |        | Free.    | Alb.-minhold. |           | Nitrates.   | Nitrites. |                  |                                |                                |
| January, . .   | 1,282,400                                        | 34                      | 33        | .24    | .0187    | .0088         | .30       | .0260       | .0000     | .25              | 75                             | 185                            |
| February, . .  | 1,054,200                                        | 32                      | 32        | .25    | .0189    | .0098         | .33       | .0340       | .0000     | .32              | 81                             | 410                            |
| March, . . .   | 2,642,600                                        | 36                      | 32        | .33    | .0062    | .0093         | .26       | .0380       | .0000     | .36              | 82                             | 58                             |
| April, . . .   | 2,603,000                                        | 39                      | 36        | .45    | .0007    | .0111         | .19       | .0250       | .0000     | .40              | 86                             | 52                             |
| May, . . . .   | 4,345,600                                        | 61                      | 61        | .31    | .0005    | .0083         | .16       | .0370       | .0000     | .33              | 73                             | 32                             |
| June, . . . .  | 3,702,600                                        | 71                      | 73        | .26    | .0004    | .0074         | .23       | .0330       | .0000     | .26              | 57                             | 33                             |
| July, . . . .  | 3,809,200                                        | 72                      | 73        | .22    | .0006    | .0088         | .26       | .0430       | .0000     | .25              | 58                             | 24                             |
| August, . . .  | 3,815,000                                        | 73                      | 72        | .17    | .0004    | .0065         | .29       | .0410       | .0000     | .19              | 69                             | 12                             |
| September, .   | 3,930,800                                        | 71                      | 69        | .16    | .0005    | .0073         | .30       | .0540       | .0000     | .16              | 71                             | 9                              |
| October, . . . | 3,634,800                                        | 51                      | 48        | .58    | .0012    | .0157         | .20       | .0220       | .0000     | .63              | 74                             | 16                             |
| November, . .  | 2,759,400                                        | 44                      | 44        | .43    | .0005    | .0109         | .18       | .0150       | .0000     | .46              | 97                             | 8                              |
| December, . .  | 1,018,200                                        | 35                      | 35        | .39    | .0008    | .0080         | .20       | .0270       | .0000     | .31              | 82                             | 15                             |

*Filter No. 7 A.*

This continuous filter was started July 20, 1894, and contained 24 inches in depth of sand of an effective size of 0.26 millimeter. Its history for the year 1894 has been published in the annual report of the Board. The principal features in the history of the filter during 1895 are as follows:—

After draining, the filter went out of operation for the winter on December 28, 1894. On March 24, 1895, it was filled slowly from below with city (filtered) water and allowed to stand for thirty-six hours. March 26 the filter began to filter canal water continuously at a prescribed rate of 2,000,000 gallons per acre daily. This rate was increased permanently, on May 1, to 5,000,000 gallons. July 1, for a period of sixteen hours, the filter ran at a rate of 5,250,000 gallons. A trap was attached to the filter so that the point of delivery was nearly opposite to the outlet. Owing to high water the gate on the outlet remained closed from April 10 to 13, and the surface of the sand covered with water. The gate was opened April

13 and remained open for thirty-four hours, but was closed again in consequence of high water. On April 19 the gate was opened and the filter allowed to drain until the 24th. Several inches of river silt were scraped from the surface on the 20th. City (filtered) water was applied slowly from below on April 24, until it covered the surface of the sand. Having stood full of water over night, the filter again went into operation on April 25 at the prescribed rate (5,000,000 gallons per acre daily). In consequence of low water in the canal the gate on the outlet remained closed, and the surface of the sand covered with water, for periods varying from eight to twenty-seven hours, on the following dates: March 30, April 27, May 5, June 8, 16, 23, July 6, 13, 21, August 3 and November 23.

In order to remove clogging at the surface, one-half an inch (approximately) of sand was removed from the surface of the filter by scraping on May 16, June 4, 26, July 17, August 7, 27, September 7, 26, October 12, 23, November 12 and 23. After scraping, the filter was raked to a depth of 1 inch, and then filled slowly with city (filtered) water from below. After filling with city water and before turning on the canal water the filter was allowed to stand for a period varying from eight to eighteen hours. Attention is called to the fact that this filter was scraped frequently to remove clogging during 1895, instead of being simply raked, as in 1894. After draining, the filter went out of operation November 25.

To test the bacterial efficiency of the filter four samples of effluent have been collected daily at different hours (Sundays excepted) and analyzed. Averages of these hourly samples, calculated for the whole period of twenty-four hours, are given in the record of daily analyses in the following table. A solution seeded with *Bacillus prodigiosus* was applied to the filter in the ratio of 1 part to 170,000 of the applied canal water from August 20 to November 19. A few of these organisms appeared in the effluent occasionally, as indicated in the table.

*Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter  
No. 7 A, 1895.*

| DAY.          | April. | May. | June. | July. | August. | SEPTEMBER.         |                | OCTOBER.           |                | NOVEMBER.          |                |
|---------------|--------|------|-------|-------|---------|--------------------|----------------|--------------------|----------------|--------------------|----------------|
|               |        |      |       |       |         | Water<br>Bacteria. | B. Prodigiosa. | Water<br>Bacteria. | B. Prodigiosa. | Water<br>Bacteria. | B. Prodigiosa. |
| 1, . . . . .  | -      | 147  | 27    | 45    | 20      | -                  | -              | 38                 | 1              | 10                 | 0              |
| 2, . . . . .  | -      | 89   | -     | 34    | 22      | 33                 | -              | 24                 | 0              | 14                 | 0              |
| 3, . . . . .  | -      | 78   | 23    | 26    | 21      | 23                 | 0              | 55                 | 0              | -                  | -              |
| 4, . . . . .  | 153    | 69   | 40    | -     | -       | 127                | 0              | 44                 | 0              | 15                 | 0              |
| 5, . . . . .  | 186    | -    | 70    | 25    | 50      | 29                 | 1              | 33                 | 0              | 12                 | 0              |
| 6, . . . . .  | 146    | 33   | 110   | 16    | 74      | 18                 | 0              | -                  | -              | 16                 | 0              |
| 7, . . . . .  | -      | 37   | 52    | -     | 54      | 55                 | 0              | 19                 | 0              | 17                 | 0              |
| 8, . . . . .  | 124    | 42   | 22    | 26    | 70      | -                  | -              | 38                 | 0              | 19                 | 0              |
| 9, . . . . .  | 106    | 31   | -     | 23    | 42      | 76                 | 12             | 28                 | 0              | 19                 | 0              |
| 10, . . . . . | 113    | 29   | 39    | 28    | 35      | 113                | 8              | 22                 | 0              | -                  | -              |
| 11, . . . . . | -      | 25   | 27    | 29    | -       | 38                 | 1              | 24                 | 0              | 10                 | 0              |
| 12, . . . . . | -      | -    | 19    | 45    | 24      | 32                 | 1              | 15                 | 0              | 21                 | 0              |
| 13, . . . . . | -      | 20   | 18    | 37    | 62      | 25                 | 0              | -                  | -              | 68                 | 0              |
| 14, . . . . . | -      | 25   | 19    | -     | 63      | 22                 | 0              | 176                | 4              | 58                 | 0              |
| 15, . . . . . | -      | 12   | 37    | 47    | 33      | -                  | -              | 165                | 4              | 74                 | 0              |
| 16, . . . . . | -      | 48   | -     | 22    | 27      | 14                 | 0              | 45                 | 3              | 212                | 1              |
| 17, . . . . . | -      | 64   | 38    | 31    | 30      | 13                 | 0              | 41                 | 0              | -                  | -              |
| 18, . . . . . | -      | 62   | 23    | 176   | -       | 12                 | 0              | 62                 | 0              | 72                 | 1              |
| 19, . . . . . | -      | -    | 19    | 107   | 38      | 27                 | 0              | 91                 | 0              | 51                 | 0              |
| 20, . . . . . | -      | 31   | 42    | 67    | 16      | 17                 | 0              | -                  | -              | 46                 | 0              |
| 21, . . . . . | -      | 44   | 21    | -     | 17      | 24                 | 0              | 108                | 0              | 30                 | 0              |
| 22, . . . . . | -      | 27   | 26    | 58    | 18      | -                  | -              | 24                 | 0              | 41                 | 0              |
| 23, . . . . . | -      | 30   | -     | 43    | 33      | 274                | 0              | 37                 | 0              | 60                 | 0              |
| 24, . . . . . | -      | 34   | 215   | 24    | 33      | 24                 | 0              | 73                 | 5              | -                  | -              |
| 25, . . . . . | 1,027  | 30   | 76    | 32    | -       | 37                 | 0              | 70                 | 3              | -                  | -              |
| 26, . . . . . | 433    | -    | 105   | 35    | 22      | 70                 | 0              | 55                 | 3              | -                  | -              |
| 27, . . . . . | 97     | 26   | 140   | 25    | 65      | 82                 | 41             | -                  | -              | -                  | -              |
| 28, . . . . . | -      | 21   | 170   | -     | 356     | 39                 | 1              | 15                 | 0              | -                  | -              |
| 29, . . . . . | 132    | 12   | 86    | 29    | 231     | -                  | -              | 15                 | 0              | -                  | -              |
| 30, . . . . . | 106    | 11   | -     | 43    | 84      | 52                 | 0              | 12                 | 0              | -                  | -              |
| 31, . . . . . | 147    | 26   | -     | 25    | 38      | -                  | -              | 10                 | 0              | -                  | -              |



*Monthly Averages of Analyses of Effluent of Filter No. 7 A.*

[Parts per 100,000.]

| 1895.          | Quantity of Effluent.<br>—<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent of Dissolved Oxygen. | Bacteria per Cubic Centimeter. |
|----------------|-------------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|-------------------------------|--------------------------------|
|                |                                                       | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                               |                                |
| March, . . .   | 1,605,200                                             | 36                      | 38        | .13    | .0012    | .0104       | .15       | .1180       | .0000     | .17              | —                             | 560                            |
| April, . . .   | 1,042,600                                             | 39                      | 37        | .47    | .0040    | .0128       | .19       | .0230       | .0000     | .41              | 86                            | 92                             |
| May, . . .     | 4,526,800                                             | 61                      | 62        | .33    | .0005    | .0097       | .16       | .0250       | .0000     | .34              | 75                            | 43                             |
| June, . . .    | 3,950,000                                             | 71                      | 74        | .29    | .0004    | .0090       | .23       | .0240       | .0000     | .29              | 21                            | 132                            |
| July, . . .    | 4,465,600                                             | 72                      | 74        | .24    | .0008    | .0093       | .26       | .0260       | .0000     | .27              | 22                            | 39                             |
| August, . . .  | 4,376,800                                             | 73                      | 73        | .19    | .0005    | .0078       | .29       | .0240       | .0000     | .23              | 39                            | 46                             |
| September, . . | 4,054,400                                             | 71                      | 71        | .18    | .0012    | .0084       | .30       | .0380       | .0006     | .19              | 40                            | 23                             |
| October, . . . | 4,362,600                                             | 51                      | 52        | .52    | .0011    | .0151       | .21       | .0230       | .0000     | .61              | 30                            | 26                             |
| November, . .  | 4,328,600                                             | 44                      | 44        | .46    | .0005    | .0123       | .18       | .0170       | .0000     | .53              | 85                            | 36                             |

*Filter No. 8 A.*

This continuous filter was started Sept. 26, 1893, and contained 60 inches in depth of sand of an effective size of 0.23 millimeter. The history of this filter up to Jan. 1, 1895, has been published in previous reports of the Board. The principal features in its history during 1895 are presented in the following paragraphs.

From Dec. 29, 1894, to March 11, 1895, the prescribed rate of filtration was 1,500,000 gallons per acre daily. On March 12 the rate was increased to 5,000,000 gallons. The filter continued in operation at this rate until November 25, when the rate was decreased to 2,000,000 gallons per acre daily. A trap was attached to the outlet. On January 31 the feed-pipe froze, and the filter remained out of service, with the surface of the sand uncovered with water, from February 1 to 6. On the 7th, city (filtered) water was applied from below until the surface became covered. After standing full of water over night the filter was started February 8. Owing to high water in the river the filter remained out of regular service from April 10 to 13, the surface of the sand being covered with water. The outlet was opened on the 13th and remained open for thirty-four hours. The filter was drained on the 19th; the river

silt was removed on the 20th; city water applied from below on the 21st until the surface was covered and the filter was then allowed to rest until the 26th. In consequence of low water in the canal the gate on the outlet remained closed and the surface covered with water on March 30, April 27, May 5, June 8, 16, 23, July 6, 13, 21, 25, August 3, 28, September 23, 28 and November 22, for periods varying from eight to thirty-six hours.

In order to remove clogging, 1 inch of sand was scraped from the surface of the filter on January 25, March 11 and 27.

After scraping on March 27 the filter was restored to its original depth with fresh sand. One-half an inch (approximately) of sand was removed by scraping on May 9, 23, June 11, 29, July 16, August 2, 20, September 2, 18, October 4, 17, 28, November 12 and December 18. After scraping, the filter was raked 1 inch deep, filled slowly with city (filtered) water from below, and allowed to stand with the surface covered by water, for periods varying from nine to thirty-four hours. On May 9, for purposes of experiment, the filter was filled with canal water from above after scraping. As the surface was found to be uncovered on February 1, 6, September 22 and December 16, city water was applied from below and the filter allowed to stand full of water for several hours. On November 10 the surface of the filter was spaded 6 inches deep.

A solution seeded with *Bacillus prodigiosus* was mixed with the applied canal water in the ratio of 1 to 170,000 parts for ten hours a day (excepting Sundays) from March 11 to April 10 and from May 6 to November 19; and in the proportion of 1 part to 85,000 parts from November 21 to December 1. Several samples were collected for bacterial analyses daily (excepting Sundays) from the effluent. Averages of these determinations, calculated for twenty-four-hour periods, will be found in the record of daily analyses in the following table:—

Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 8 A, 1895.

| Date. | January.        |                | February.       |                | MARCH.          |                | APRIL.          |                | MAY.            |                | JUNE.           |                | JULY.           |                | AUGUST.         |                | SEPTEMBER.      |                | OCTOBER.        |                | NOVEMBER.       |                | December.       |                |
|-------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|
|       | Water Bacteria. | B. Prodigiosa. | Water Bacteria. | B. Prodigiosa. | Water Bacteria. | B. Prodigiosa. | Water Bacteria. | B. Prodigiosa. | Water Bacteria. | B. Prodigiosa. | Water Bacteria. | B. Prodigiosa. | Water Bacteria. | B. Prodigiosa. | Water Bacteria. | B. Prodigiosa. | Water Bacteria. | B. Prodigiosa. | Water Bacteria. | B. Prodigiosa. | Water Bacteria. | B. Prodigiosa. | Water Bacteria. | B. Prodigiosa. |
| 1.    | 14              |                | 18              |                | 22              |                | 78              |                | 16              |                | 21              |                | 22              |                | 15              |                | 37              |                | 13              |                | 13              |                | 13              |                |
| 2.    | 13              |                | 18              |                | 12              |                | 60              |                | 21              |                | 23              |                | 17              |                | 14              |                | 5               |                | 22              |                | 0               |                | 0               |                |
| 3.    | 16              |                | 17              |                | 26              |                | 43              |                | 20              |                | 17              |                | 12              |                | 9               |                | 11              |                | 7               |                | 0               |                | 0               |                |
| 4.    | 18              |                | 17              |                | 19              |                | 87              |                | 44              |                | 26              |                | 15              |                | 96              |                | 13              |                | 7               |                | 0               |                | 0               |                |
| 5.    | 22              |                | 57              |                | 16              |                | 77              |                | 15              |                | 17              |                | 0               |                | 0               |                | 6               |                | 20              |                | 0               |                | 0               |                |
| 6.    | 22              |                | 57              |                | 16              |                | 77              |                | 0               |                | 18              |                | 0               |                | 13              |                | 13              |                | 0               |                | 0               |                | 0               |                |
| 7.    | 32              |                | 57              |                | 16              |                | 77              |                | 14              |                | 21              |                | 0               |                | 12              |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 8.    | 32              |                | 57              |                | 16              |                | 77              |                | 0               |                | 18              |                | 0               |                | 10              |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 9.    | 32              |                | 57              |                | 16              |                | 77              |                | 0               |                | 18              |                | 0               |                | 10              |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 10.   | 30              |                | 100             |                | 17              |                | 16              |                | 17              |                | 19              |                | 0               |                | 0               |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 11.   | 36              |                | 60              |                | 101             |                | 16              |                | 16              |                | 19              |                | 0               |                | 0               |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 12.   | 42              |                | 60              |                | 101             |                | 16              |                | 16              |                | 19              |                | 0               |                | 0               |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 13.   | 83              |                | 77              |                | 328             |                | 18              |                | 18              |                | 35              |                | 0               |                | 0               |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 14.   | 88              |                | 34              |                | 1,225           |                | 14              |                | 0               |                | 41              |                | 0               |                | 23              |                | 11              |                | 0               |                | 0               |                | 0               |                |
| 15.   | 40              |                | 42              |                | 922             |                | 13              |                | 0               |                | 21              |                | 0               |                | 16              |                | 0               |                | 16              |                | 0               |                | 0               |                |
| 16.   | 48              |                | 45              |                | 626             |                | 21              |                | 0               |                | 18              |                | 0               |                | 26              |                | 0               |                | 4               |                | 0               |                | 0               |                |
| 17.   | 32              |                | 92              |                | 243             |                | 12              |                | 0               |                | 33              |                | 0               |                | 9               |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 18.   | 37              |                | 92              |                | 243             |                | 11              |                | 0               |                | 16              |                | 0               |                | 13              |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 19.   | 28              |                | 96              |                | 374             |                | 11              |                | 0               |                | 16              |                | 0               |                | 6               |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 20.   | 31              |                | 44              |                | 110             |                | 113             |                | 0               |                | 18              |                | 0               |                | 11              |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 21.   | 28              |                | 21              |                | 96              |                | 47              |                | 0               |                | 10              |                | 0               |                | 20              |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 22.   | 23              |                | 18              |                | 63              |                | 16              |                | 0               |                | 135             |                | 0               |                | 26              |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 23.   | 39              |                | 34              |                | 27              |                | 30              |                | 0               |                | 0               |                | 0               |                | 25              |                | 0               |                | 1               |                | 0               |                | 0               |                |
| 24.   | 39              |                | 27              |                | 46              |                | 13              |                | 0               |                | 70              |                | 0               |                | 24              |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 25.   | 27              |                | 24              |                | 36              |                | 29              |                | 0               |                | 23              |                | 0               |                | 10              |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 26.   | 84              |                | 20              |                | 31              |                | 18              |                | 0               |                | 19              |                | 0               |                | 16              |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 27.   | 56              |                | 31              |                | 63              |                | 34              |                | 0               |                | 29              |                | 0               |                | 11              |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 28.   | 43              |                | 18              |                | 69              |                | 25              |                | 0               |                | 29              |                | 0               |                | 0               |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 29.   | 30              |                | 21              |                | 69              |                | 28              |                | 0               |                | 18              |                | 0               |                | 11              |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 30.   | 18              |                | 20              |                | 69              |                | 23              |                | 0               |                | 22              |                | 0               |                | 0               |                | 0               |                | 0               |                | 0               |                | 0               |                |
| 31.   | 18              |                | 18              |                | 20              |                | 17              |                | 0               |                | 13              |                | 0               |                | 14              |                | 0               |                | 0               |                | 0               |                | 0               |                |

*Monthly Averages of Analyses of Effluent of Filter No. 8 A.*

[Parts per 100,000.]

| 1895.          | Quantity of Effluent, Gallons per Acre Daily. | TEMPERATURE DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | Bacteria per Cubic Centimeter. |
|----------------|-----------------------------------------------|---------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|
|                |                                               | Applied Water.      | Effluent. |        | Free.    | Albaminoid. |           | Nitrates.   | Nitrites. |                  |                                |                                |
| January, . .   | 1,484,400                                     | 34                  | 33        | .24    | .0110    | .0069       | .31       | .0340       | .0000     | .25              | 70                             | 36                             |
| February, . .  | 1,296,600                                     | 32                  | 34        | .24    | .0059    | .0089       | .33       | .0370       | .0000     | .31              | 53                             | 19                             |
| March, . . .   | 2,914,200                                     | 36                  | 33        | .33    | .0027    | .0090       | .26       | .0420       | .0000     | .37              | 76                             | 65                             |
| April, . . .   | 2,615,200                                     | 39                  | 36        | .46    | .0004    | .0098       | .19       | .0230       | .0000     | .40              | 81                             | 63                             |
| May, . . . .   | 4,490,400                                     | 61                  | 61        | .31    | .0002    | .0072       | .16       | .0290       | .0000     | .32              | 55                             | 20                             |
| June, . . . .  | 4,162,000                                     | 71                  | 74        | .26    | .0002    | .0062       | .23       | .0280       | .0000     | .25              | 41                             | 25                             |
| July, . . . .  | 4,656,000                                     | 72                  | 74        | .24    | .0006    | .0077       | .26       | .0280       | .0001     | .26              | 21                             | 32                             |
| August, . . .  | 4,438,400                                     | 73                  | 73        | .19    | .0009    | .0076       | .29       | .0250       | .0000     | .20              | 19                             | 20                             |
| September, .   | 4,335,800                                     | 71                  | 71        | .18    | .0008    | .0082       | .30       | .0360       | .0009     | .18              | 25                             | 17                             |
| October, . . . | 4,455,800                                     | 51                  | 52        | .53    | .0011    | .0145       | .21       | .0230       | .0000     | .60              | 31                             | 28                             |
| November, . .  | 4,024,000                                     | 44                  | 44        | .45    | .0005    | .0110       | .18       | .0170       | .0000     | .46              | 81                             | 39                             |
| December, . .  | 1,592,000                                     | 35                  | 36        | .39    | .0007    | .0078       | .19       | .0310       | .0000     | .31              | 80                             | 8                              |

*Filter No. 18 A.*

This intermittent filter, 20 inches in diameter, was started Sept. 17, 1889, and contained 62 inches in depth of sand of an effective size of 0.48 millimeter. The history of this filter up to Dec. 31, 1894, has been published in previous reports of the Board. The principal points in its history during 1895 are as follows:—

From Dec. 1, 1894, to April 30, 1895, the filter was not operated. On May 1, after having been filled slowly from below with city (filtered) water, it was put in operation at a prescribed rate of 5,700,000 gallons per acre daily. The depth of sand in the filter was 59 inches. The period of intermittent operation was arranged in such a manner that the surface remained uncovered for two hours during the day, excepting on Sundays, when the filter ran continuously. A trap was attached to the outlet in such a manner that the point of discharge was a little below the outlet and the lower layers of the filter were not kept saturated. Owing to a stoppage in the canal water pipe the surface of the filter was found to be uncovered, and no effluent running, on May 25, June 17 and July 26. In consequence of low water the filter was not in operation from fifteen to twenty hours on June 8, July 6, 13, August 3, September 22 and 28. During these periods the surface of the sand remained covered with water.

In order to remove clogging, the filter was scraped as follows: June 24, 0.63 inch in depth of sand was removed; August 16, 0.57 inch; August 31 enough sand was removed to reduce the total depth of filtering material to 3 feet; November 5, 0.73 inch. This filter was not raked and filled with city water from below, as in the case of No. 3 B, but, as in the cases of the other small filters, canal water was applied from above after scraping. On September 13 the rate of filtration was fluctuated by closing the gate in the outlet for a minute and then opening it quickly to the usual point. On November 2 and 22 the rate was fluctuated by throwing the gate wide open for one minute and then reducing the rate quickly to the original rate.

A solution seeded with *Bacillus prodigiosus* was mixed with the applied canal water, in the ratio of 1 part to 170,000 parts, for ten hours a day, from November 19 to 23. Samples of the effluent were analyzed daily (excepting Sundays and on certain other occasions), and the record of these daily bacterial analyses will be found in the following table:—

*Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 18 A, 1895.*

| DAY.          | May.  | June. | July. | August. | September. | October. | November. |
|---------------|-------|-------|-------|---------|------------|----------|-----------|
| 1, . . . . .  | 1,820 | 22    | 72    | 32      | -          | 102      | 36        |
| 2, . . . . .  | 1,120 | -     | 52    | 47      | 104        | -        | 51        |
| 3, . . . . .  | 215   | 45    | 63    | 33      | 75         | 10,360   | -         |
| 4, . . . . .  | 574   | 22    | -     | -       | 175        | -        | 85        |
| 5, . . . . .  | -     | 39    | 37    | 11      | 660        | 1,890    | -         |
| 6, . . . . .  | 160   | 18    | 136   | 24      | 250        | -        | 120       |
| 7, . . . . .  | 170   | 26    | -     | 67      | -          | 239      | -         |
| 8, . . . . .  | 126   | 39    | 43    | 40      | -          | 270      | 45        |
| 9, . . . . .  | 82    | -     | 51    | 8       | 58         | -        | -         |
| 10, . . . . . | 122   | 29    | 65    | 18      | 24         | -        | -         |
| 11, . . . . . | 83    | 52    | 125   | -       | 40         | -        | 30        |
| 12, . . . . . | -     | 42    | 148   | 16      | 80         | 259      | 80        |
| 13, . . . . . | 88    | 72    | 98    | 18      | 37         | -        | 24        |
| 14, . . . . . | 45    | 68    | -     | 24      | -          | 130      | -         |
| 15, . . . . . | 58    | 104   | 78    | 23      | -          | 360      | 55        |
| 16, . . . . . | 46    | -     | 65    | 15      | 39         | -        | -         |
| 17, . . . . . | 37    | 88    | 170   | 44      | 26         | 122      | -         |
| 18, . . . . . | 30    | 58    | 105   | -       | 23         | 136      | 97        |
| 19, . . . . . | -     | 97    | 60    | 31      | 1,890      | -        | 120       |
| 20, . . . . . | 490   | 65    | 40    | 14      | 470        | -        | -         |
| 21, . . . . . | 165   | 112   | -     | 32      | 490        | -        | -         |
| 22, . . . . . | 70    | 128   | 45    | 22      | -          | 89       | -         |
| 23, . . . . . | 50    | -     | 37    | 35      | 310        | 55       | 140       |
| 24, . . . . . | 50    | 143   | 35    | 13      | 115        | -        | -         |
| 25, . . . . . | 20    | 67    | 32    | -       | -          | 87       | -         |
| 26, . . . . . | -     | 107   | 25    | 20      | 155        | 58       | -         |
| 27, . . . . . | 37    | 127   | 27    | 20      | -          | -        | -         |
| 28, . . . . . | 53    | 172   | -     | 26      | 190        | -        | -         |
| 29, . . . . . | 87    | 81    | 26    | 20      | -          | -        | -         |
| 30, . . . . . | 63    | -     | 42    | 19      | -          | 29       | -         |
| 31, . . . . . | 42    | -     | 8     | 7       | -          | -        | -         |

*Monthly Averages of Analyses of Effluent of Filter No. 18 A.*

[Parts per 100,000.]

| 1895.          | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE<br>DEG. F. |           | Color. | AMMONIA. |              | Chlorine. | NITROGEN<br>AS |          | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | Bacteria per cubic Centimeter. |
|----------------|--------------------------------------------------|------------------------|-----------|--------|----------|--------------|-----------|----------------|----------|------------------|--------------------------------|--------------------------------|
|                |                                                  | Applied Water.         | Effluent. |        | Free.    | Alb.-minoid. |           | Nitrate.       | Nitrite. |                  |                                |                                |
| May, . . .     | 4,960,000                                        | 61                     | 58        | .36    | .0002    | .0090        | .16       | .0220          | .0000    | .34              | 61                             | 80                             |
| June, . . .    | 4,380,000                                        | 71                     | 73        | .30    | .0006    | .0096        | .21       | .0230          | .0000    | .32              | 44                             | 69                             |
| July, . . .    | 4,300,000                                        | 72                     | 72        | .25    | .0005    | .0086        | .25       | .0290          | .0000    | .26              | 43                             | 35                             |
| August, . . .  | 4,280,000                                        | 73                     | 73        | .18    | .0005    | .0088        | .29       | .0300          | .0000    | .21              | 45                             | 20                             |
| September, . . | 4,680,000                                        | 71                     | 70        | .19    | .0011    | .0092        | .30       | .0300          | .0000    | .19              | 11                             | 98                             |
| October, . . . | 4,940,000                                        | 51                     | 53        | .46    | .0014    | .0145        | .23       | .0250          | .0000    | .52              | 56                             | 163                            |
| November, . .  | 4,660,000                                        | 44                     | 43        | .59    | .0014    | .0171        | .20       | .0190          | .0000    | .63              | 96                             | 120                            |

*Filter No. 33 A.*

This continuous filter was started April 28, 1892, and contained 60 inches in depth of sand of an effective size of 0.14 millimeter. The history of the filter up to Dec. 31, 1894, has been published in previous reports of the Board. The principal points for the year 1895 are as follows :—

From Dec. 1, 1894, to April 30, 1895, the filter was not in operation. On May 1, 1895, with a depth of sand of 58 inches, after having been filled slowly with city (filtered) water from below, the filter was put in operation at a prescribed rate of 2,000,000 gallons per acre daily. A trap was attached to the outlet. Owing to low water in the canal the filter was not in operation from twenty-four to thirty-nine hours on June 8, July 6, 13, August 3, September 22 and 28. For purposes of experiment the gate on the outlet pipe was closed for one minute and then opened to the original point on September 13, October 3 and 4. On October 10 the gate was thrown wide open for one minute and then closed to the usual point. The surface of the filter was scraped to remove clogging as follows : on June 24, 0.27 inch in depth of sand was removed from the surface ; July 6, 0.24 inch ; July 31, 0.26 inch ; August 16, 0.29 inch ; August 30, 0.30 inch ; September 21, 0.39 inch ; October 11, 0.27 inch ; October 24, 0.39 inch ; and November 19, 0.33 inch. After scraping, this filter was raked and filled with canal water from above and put in operation at once. A record of the daily (excepting Sundays) bacterial analyses will be found in the following table :—

*Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 33 A, 1895.*

| DAY.          | May. | June. | July. | August. | September. | October. | November. |
|---------------|------|-------|-------|---------|------------|----------|-----------|
| 1, . . . . .  | 210  | 35    | 40    | 39      | -          | 17       | 34        |
| 2, . . . . .  | 135  | -     | 18    | 19      | -          | -        | 5         |
| 3, . . . . .  | 70   | 13    | 21    | 47      | 26         | 1,610    | -         |
| 4, . . . . .  | 48   | 81    | -     | -       | 25         | 1,260    | 5         |
| 5, . . . . .  | -    | 30    | 76    | 75      | 124        | 340      | -         |
| 6, . . . . .  | 22   | 35    | 37    | 34      | 66         | -        | 20        |
| 7, . . . . .  | 44   | 270   | -     | 74      | -          | 120      | -         |
| 8, . . . . .  | 47   | 20    | 26    | 44      | -          | 168      | 34        |
| 9, . . . . .  | 46   | -     | 5     | 45      | 19         | -        | -         |
| 10, . . . . . | 38   | 280   | 250   | 18      | 21         | 325      | -         |
| 11, . . . . . | 24   | 68    | 72    | -       | 24         | 47       | 23        |
| 12, . . . . . | -    | 80    | 293   | 19      | 15         | 112      | 35        |
| 13, . . . . . | 25   | 34    | 145   | 28      | 80         | -        | 8         |
| 14, . . . . . | 23   | 44    | -     | 32      | -          | 37       | -         |
| 15, . . . . . | 23   | 160   | 68    | 34      | -          | 27       | 46        |
| 16, . . . . . | 82   | -     | 62    | 27      | 14         | -        | -         |
| 17, . . . . . | 61   | 98    | 102   | 26      | 6          | 35       | -         |
| 18, . . . . . | 11   | 35    | 123   | -       | 12         | 66       | 57        |
| 19, . . . . . | -    | 120   | 44    | 40      | 79         | -        | 19        |
| 20, . . . . . | 74   | 77    | 61    | 10      | 63         | -        | -         |
| 21, . . . . . | 660  | 34    | -     | 43      | 90         | -        | -         |
| 22, . . . . . | 31   | 29    | 30    | 45      | -          | 32       | -         |
| 23, . . . . . | 31   | -     | 34    | 41      | 154        | 20       | 15        |
| 24, . . . . . | 480  | 57    | 27    | 33      | 41         | -        | -         |
| 25, . . . . . | 25   | 490   | 31    | -       | -          | 51       | -         |
| 26, . . . . . | -    | 50    | 31    | 54      | 30         | 27       | -         |
| 27, . . . . . | 30   | 32    | 21    | 38      | -          | -        | -         |
| 28, . . . . . | 34   | 117   | -     | 22      | 26         | -        | -         |
| 29, . . . . . | 32   | 62    | 16    | 16      | -          | -        | -         |
| 30, . . . . . | 36   | -     | 18    | 18      | -          | 27       | -         |
| 31, . . . . . | 45   | -     | 31    | 4       | -          | -        | -         |

*Monthly Averages of Analyses of Effluent of Filter No. 33 A.*

[Parts per 100,000.]

| 1895.        | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |              | Chlorine. | NITROGEN<br>as |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | Bacteria per Cubic Centimeter. |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|--------------|-----------|----------------|-----------|------------------|--------------------------------|--------------------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Alb.-minoid. |           | Nitrates.      | Nitrites. |                  |                                |                                |
| May, . . .   | 2,020,000                                        | 61                      | 61        | .35    | .0006    | .0095        | .17       | .0230          | .0000     | .32              | 39                             | 262                            |
| June, . . .  | 1,860,000                                        | 71                      | 72        | .26    | .0013    | .0090        | .24       | .0230          | .0007     | .28              | 6                              | 94                             |
| July, . . .  | 1,860,000                                        | 72                      | 69        | .25    | .0007    | .0075        | .26       | .0280          | .0009     | .26              | 18                             | 102                            |
| August, . .  | 1,960,000                                        | 73                      | 73        | .20    | .0033    | .0092        | .30       | .0140          | .0012     | .23              | 5                              | 32                             |
| September, . | 1,920,000                                        | 71                      | 71        | .19    | .0016    | .0078        | .30       | .0220          | .0010     | .18              | 1                              | 23                             |
| October, . . | 1,940,000                                        | 51                      | 53        | .40    | .0009    | .0118        | .28       | .0250          | .0000     | .45              | 29                             | 27                             |
| November, .  | 1,980,000                                        | 44                      | 47        | .55    | .0015    | .0131        | .20       | .0210          | .0000     | .55              | 73                             | 20                             |

*Filter No. 38.*

This continuous filter was started on April 28, 1892, and contained 24 inches in depth of sand of an effective size of 0.20 millimeter. The history of the filter up to Dec. 31, 1894, has been published in previous reports of the Board. The principal points in its history during 1895 are as follows:—

The depth of sand in the filter on Jan. 1, 1895, was 18 inches. From Dec. 1, 1894, to April 30, 1895, the filter was not in operation. On May 1, 1895, after having been filled slowly with city (filtered) water from below, the filter was put in operation at a prescribed rate of 1,000,000 gallons per acre daily. A trap was attached to the outlet. Owing to low water in the canal the filter was not in operation, for periods varying from thirty-four to thirty-nine hours, on June 8, July 6, 13 and August 3. The filter was allowed to stand full of water during these periods. In order to remove clogging the surface of the filter was scraped as follows: on July 31, 0.31 inch of sand was removed, and on August 21, 1 inch of sand was removed to show the effect of deep scraping. After scraping, the filter was not raked, but filled with canal water from above and put into operation at once. A sample of the effluent was collected daily (excepting Sundays) for bacterial analysis and the results are recorded in the following table:—



*Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter  
No. 38, 1895.*

| DAY.          | May.  | June. | July. | August. |
|---------------|-------|-------|-------|---------|
| 1, . . . . .  | 2,450 | 18    | 29    | 75      |
| 2, . . . . .  | 960   | -     | 25    | 29      |
| 3, . . . . .  | 127   | 70    | 28    | 26      |
| 4, . . . . .  | 168   | 17    | -     | -       |
| 5, . . . . .  | -     | 47    | 21    | 105     |
| 6, . . . . .  | 176   | 26    | 23    | 6       |
| 7, . . . . .  | -     | 19    | -     | 17      |
| 8, . . . . .  | -     | 40    | 68    | 8       |
| 9, . . . . .  | 70    | -     | 52    | 19      |
| 10, . . . . . | 58    | 240   | 72    | 9       |
| 11, . . . . . | 106   | 138   | 150   | -       |
| 12, . . . . . | -     | 13    | 175   | 34      |
| 13, . . . . . | 38    | 35    | 72    | 17      |
| 14, . . . . . | 44    | 350   | -     | 18      |
| 15, . . . . . | 32    | 30    | 320   | 16      |
| 16, . . . . . | 35    | -     | 90    | 23      |
| 17, . . . . . | 22    | 32    | 156   | 24      |
| 18, . . . . . | 22    | 27    | 101   | -       |
| 19, . . . . . | -     | 285   | 45    | 18      |
| 20, . . . . . | 50    | 31    | 68    | 40      |
| 21, . . . . . | 20    | 35    | -     | 75      |
| 22, . . . . . | 18    | 90    | 40    | 30      |
| 23, . . . . . | 45    | -     | 40    | 21      |
| 24, . . . . . | 350   | 110   | 47    | 14      |
| 25, . . . . . | 25    | 50    | 50    | -       |
| 26, . . . . . | -     | 59    | 35    | 41      |
| 27, . . . . . | 44    | 58    | 32    | -       |
| 28, . . . . . | 34    | 104   | -     | 14      |
| 29, . . . . . | 21    | 73    | 18    | 24      |
| 30, . . . . . | 16    | -     | 22    | -       |
| 31, . . . . . | 23    | -     | 210   | -       |

*Monthly Averages of Analyses of Effluent of Filter No. 38.*

[Parts per 100,000.]

| 1895.       | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed | Per Cent. of Dissolved Oxygen. | Bacteria per Cubic Centimeter. |
|-------------|--------------------------------------------------|------------------------|-----------|--------|----------|-------------|-----------|----------------|-----------|-----------------|--------------------------------|--------------------------------|
|             |                                                  | Applied Water.         | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.      | Nitrites. |                 |                                |                                |
| May, . . .  | 1,000,000                                        | 61                     | 61        | .35    | .0004    | .0091       | .17       | .0280          | .0000     | .34             | 58                             | 350                            |
| June, . . . | 960,000                                          | 71                     | 71        | .30    | .0015    | .0087       | .21       | .0260          | .0008     | .32             | 8                              | 27                             |
| July, . . . | 980,000                                          | 72                     | 69        | .25    | .0015    | .0077       | .26       | .0330          | .0008     | .26             | 10                             | 37                             |
| August, . . | 1,000,000                                        | 73                     | 74        | .19    | .0033    | .0093       | .30       | .0200          | .0011     | .23             | 6                              | 15                             |

*Filter No. 41.*

This intermittent filter was started on May 9, 1892, and contained 60 inches in depth of sand of an effective size of 0.14 millimeter. Its history up to Dec. 31, 1894, has been published in previous reports of the Board. The principal points in its history during 1895 are as follows:—

The depth of sand on Jan. 1, 1895, amounted to 58 inches. From Dec. 1, 1894, to April 30, 1895, the filter was not in operation. On May 1, 1895, after having been filled slowly with city (filtered) water from below, the filter was put in operation, filtering canal water at a rate of 2,000,000 gallons per acre daily. From that date until November 23 the surface remained uncovered for two hours during each day, excepting Sundays, when the filter ran continuously. A trap attached to the outlet prevented air from passing into the filter at that point. Owing to low water in the canal the gate on the outlet remained closed and the surface of the sand covered with water on June 8, July 6, 13 and August 3, for periods varying from thirty-three to thirty-nine hours. The surface of the filter was scraped in order to remove clogging as follows: on June 4, 0.38 inch of sand was removed; on June 18, 0.23 inch; on June 27, 0.33 inch; on July 10, 0.43 inch; on July 22, 0.37 inch; on July 30, 0.45 inch; and on August 16, 0.39 inch. After scraping, the filter was not raked nor filled with city filtered water from below, but canal water was applied at the surface. A record of daily (excepting Sundays) bacterial analyses of the effluent will be found in the following table:—

*Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter  
No. 41, 1895.*

| DAY.          | May. | June. | July. | August. |
|---------------|------|-------|-------|---------|
| 1, . . . . .  | 310  | 40    | 60    | 20      |
| 2, . . . . .  | 360  | -     | 20    | 7       |
| 3, . . . . .  | 106  | 23    | 34    | 11      |
| 4, . . . . .  | 50   | 62    | -     | -       |
| 5, . . . . .  | -    | 20    | 7     | 12      |
| 6, . . . . .  | 40   | 22    | 14    | 13      |
| 7, . . . . .  | 20   | 14    | -     | 6       |
| 8, . . . . .  | 22   | 33    | 9     | 7       |
| 9, . . . . .  | 24   | -     | 64    | 8       |
| 10, . . . . . | 19   | 6     | 25    | 13      |
| 11, . . . . . | -    | 24    | 17    | -       |
| 12, . . . . . | -    | 15    | 22    | 34      |
| 13, . . . . . | 64   | 234   | 22    | 18      |
| 14, . . . . . | 23   | 9     | -     | 31      |
| 15, . . . . . | 16   | 23    | 21    | 20      |
| 16, . . . . . | 14   | -     | 11    | 6       |
| 17, . . . . . | 25   | 25    | 7     | 10      |
| 18, . . . . . | 11   | 32    | 35    | -       |
| 19, . . . . . | -    | 56    | 20    | 7       |
| 20, . . . . . | 80   | 36    | 14    | 7       |
| 21, . . . . . | 40   | 14    | -     | 26      |
| 22, . . . . . | 24   | 32    | 20    | 14      |
| 23, . . . . . | 15   | -     | 32    | 4       |
| 24, . . . . . | 28   | 34    | 47    | 8       |
| 25, . . . . . | 33   | 167   | 27    | -       |
| 26, . . . . . | -    | 32    | 13    | 18      |
| 27, . . . . . | 70   | 12    | 12    | -       |
| 28, . . . . . | 10   | 42    | -     | 14      |
| 29, . . . . . | 17   | 37    | 37    | 24      |
| 30, . . . . . | 42   | -     | 18    | 60      |
| 31, . . . . . | 87   | -     | 9     | -       |

*Monthly Averages of Analyses of Effluent of Filter No. 41.*

[Parts per 100,000.]

| 1895.       | Quantity of Effluent. Gallons per Acre Daily. | TEMPERATURE DEG. F. |           | Color. | AMMONIA. |              | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | Bacteria per Cubic Centimeter. |
|-------------|-----------------------------------------------|---------------------|-----------|--------|----------|--------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|
|             |                                               | Applied Water.      | Effluent. |        | Free.    | Alb.-minoid. |           | Nitrates.   | Nitrites. |                  |                                |                                |
| May, . . .  | 1,960,000                                     | 61                  | 61        | .35    | .0006    | .0082        | .17       | .0280       | .0000     | .32              | 81                             | 24                             |
| June, . . . | 2,280,000                                     | 71                  | 75        | .23    | .0004    | .0071        | .24       | .0400       | .0000     | .25              | 58                             | 26                             |
| July, . . . | 1,920,000                                     | 72                  | 69        | .23    | .0003    | .0067        | .26       | .0350       | .0000     | .23              | 60                             | 21                             |
| August, . . | 1,860,000                                     | 73                  | 73        | .19    | .0011    | .0077        | .30       | .0380       | .0000     | .20              | 58                             | 10                             |

*Filter No. 42.*

This continuous filter was started Oct. 29, 1892, and contained 10 inches in depth of sand of an effective size of 0.20 millimeter. The history of the filter up to Dec. 11, 1894, has been published in previous reports of the Board. Its history during 1895 contains the following points:—

From Dec. 1, 1894, to April 30, 1895, the filter was not in operation. On May 1, 1895, with only about 7 inches of fine sand, after having been filled slowly from below with city (filtered) water, filtration of canal water at a prescribed rate of 5,000,000 gallons per acre daily was begun. A short trap attached to the outlet prevented air from entering the filter at that point. Owing to low water in the canal the gate at the outlet remained closed and the surface of the sand covered with water on June 8, July 6, 13, August 3, and September 22 and 28, for periods varying from thirty-three to thirty-nine hours. The filter was scraped to remove clogging as follows: May 11, 0.27 inch of sand was removed; May 17, 0.21 inch; May 23, 0.32 inch; May 29, 0.29 inch; June 3, 0.30 inch; June 21, 0.30 inch; June 24, 0.27 inch; June 27, 0.21 inch; June 29, 0.34 inch; July 3, 0.27 inch; July 9, 0.29 inch; July 13, 0.24 inch; July 22, 0.33 inch; July 26, 0.32 inch; July 30, 0.24 inch; August 2, 0.30 inch; August 7, 0.24 inch; August 13, 0.24 inch; August 21, 1.36 inches; August 26, 0.30 inch; August 31, 0.26 inch; September 7, 0.35 inch; September 13, 0.28 inch; September 18, 0.24 inch; September 25, 0.24 inch; October 1, 0.17 inch; October 11, 0.24 inch; October 15, 0.20 inch; October 19, 0.30 inch; October 26, 0.26 inch; November 1, 0.30 inch; and November 11, 0.32 inch. The surface was not raked after scraping and the filter was usually filled with canal water from above; but on October 1 city water was applied from below.

This, in conjunction with the condition produced by the frequent scraping, which had reduced the fine sand to the under-drains, increased the number of bacteria in the effluent from that time on.

This is made evident in the following record of daily (excepting Sundays and on certain occasions when a sample was not taken) bacterial analyses of the effluent:—

*Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 42, 1895.*

| DAY.          | May.  | June. | July. | August. | September. | October. | November. |
|---------------|-------|-------|-------|---------|------------|----------|-----------|
| 1, . . . . .  | 2,555 | 16    | 35    | 65      | -          | 525      | 770       |
| 2, . . . . .  | 1,050 | -     | 30    | 102     | -          | -        | -         |
| 3, . . . . .  | 385   | 36    | 47    | 72      | 56         | 273,000  | -         |
| 4, . . . . .  | 665   | 47    | -     | -       | 54         | -        | 690       |
| 5, . . . . .  | -     | 33    | 56    | 215     | 97         | 8,092    | -         |
| 6, . . . . .  | 145   | 18    | 64    | 81      | 62         | -        | 840       |
| 7, . . . . .  | 140   | 34    | -     | 280     | -          | 2,975    | -         |
| 8, . . . . .  | 80    | 20    | 110   | 110     | -          | 5,040    | 250       |
| 9, . . . . .  | 84    | -     | 61    | 51      | 82         | -        | -         |
| 10, . . . . . | 74    | 22    | 224   | 48      | 37         | -        | -         |
| 11, . . . . . | 98    | 26    | 190   | -       | 46         | 3,640    | 540       |
| 12, . . . . . | -     | 52    | 154   | 37      | 46         | 6,210    | -         |
| 13, . . . . . | 82    | 56    | 2,380 | 65      | -          | -        | 1,155     |
| 14, . . . . . | 34    | 245   | -     | 37      | -          | 1,020    | -         |
| 15, . . . . . | 37    | 120   | 644   | 71      | -          | 840      | 2,625     |
| 16, . . . . . | 20    | -     | 280   | 18      | 38         | -        | -         |
| 17, . . . . . | 50    | 112   | 434   | 29      | 50         | 945      | -         |
| 18, . . . . . | 50    | 75    | 135   | -       | 4,200      | 495      | 42        |
| 19, . . . . . | -     | 102   | 92    | 21      | 2,880      | -        | 4,060     |
| 20, . . . . . | 35    | 65    | 34    | 40      | 1,680      | -        | -         |
| 21, . . . . . | 184   | 53    | -     | 2,360   | 1,190      | -        | -         |
| 22, . . . . . | 490   | 130   | 38    | 2,996   | -          | 127      | -         |
| 23, . . . . . | 64    | -     | 37    | 492     | 580        | 112      | 3,570     |
| 24, . . . . . | 40    | 59    | 40    | 289     | 210        | -        | -         |
| 25, . . . . . | 16    | 48    | 40    | -       | -          | 179      | -         |
| 26, . . . . . | -     | 40    | 34    | 57      | 1,032      | 340      | -         |
| 27, . . . . . | 20    | 118   | 21    | -       | -          | -        | -         |
| 28, . . . . . | 34    | 80    | -     | 140     | 230        | 310      | -         |
| 29, . . . . . | 54    | 260   | 34    | 96      | -          | -        | -         |
| 30, . . . . . | 50    | -     | 29    | 22      | -          | 263      | -         |
| 31, . . . . . | 30    | -     | 110   | 43      | -          | -        | -         |

*Monthly Averages of Analyses of Effluent of Filter No. 42.*

[Parts per 100,000.]

| 1895.        | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per cent of Dissolved Oxygen. | Bacteria per Cubic Centimeter. |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|-------------------------------|--------------------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                               |                                |
| May, . . .   | 4,780,000                                        | 61                      | 60        | .39    | .0005    | .0100       | .17       | .0180       | .0000     | .38              | 61                            | 140                            |
| June, . . .  | 4,180,000                                        | 71                      | 71        | .30    | .0006    | .0094       | .21       | .0260       | .0010     | .34              | 38                            | 44                             |
| July, . . .  | 4,440,000                                        | 72                      | 70        | .29    | .0004    | .0097       | .26       | .0250       | .0000     | .31              | 35                            | 96                             |
| August, . .  | 4,440,000                                        | 73                      | 74        | .23    | .0013    | .0129       | .30       | .0270       | .0000     | .26              | 15                            | 50                             |
| September, . | 4,440,000                                        | 71                      | 70        | .22    | .0012    | .0117       | .30       | .0310       | .0000     | .20              | 16                            | 44                             |
| October, . . | 4,700,000                                        | 51                      | 53        | .49    | .0036    | .0180       | .23       | .0240       | .0002     | .57              | 42                            | 2,576                          |
| November, .  | 4,680,000                                        | 44                      | 46        | .64    | .0040    | .0182       | .20       | .0190       | .0000     | .62              | 95                            | 2,450                          |

*Filter No. 43.*

This continuous filter was started on May 30, 1893, and contained 60 inches in depth of sand of an effective size of 0.26 millimeter. The history of the filter up to Dec. 31, 1894, has been published in previous reports of the Board. Its history for 1895 contains the following principal points:—

From Dec. 1, 1894, to April 30, 1895, the filter was not in operation. On May 1, 1895, with a depth of fine sand equal to 57 inches, and after having been filled slowly from below with city (filtered) water, the filter began to filter canal water at a prescribed rate of 5,000,000 gallons per acre daily. A short trap attached to the outlet prevented air from entering the filter at that point. Owing to low water in the canal the gate on the outlet remained closed and the surface of the sand covered with water on June 8, July 6, 13, August 3, and September 22 and 28, for periods varying from twenty-four to thirty-nine hours. In order to remove clogging the surface was scraped as follows: on June 19, 0.20 inch of sand was removed; on June 27, 0.60 inch; on July 29, 0.38 inch; on August 1, enough sand was removed to reduce the total depth of filtering material to 36 inches; on August 27, 0.53 inch; on September 9, 0.50 inch; on September 20, 0.45 inch; on October 3, 0.39 inch; on October 16, 0.47 inch; on October 25, 0.49 inch; on November 7, 0.42 inch; on November 19, 0.49 inch. The surface was not raked after scraping and the filter was usually filled with canal water from above, but on August 1, October 25 and November 7, city (filtered) water was applied below.

The rate of filtration was fluctuated as follows: on September 7 and 30 the gate on the outlet was closed for one minute and then opened to the usual point; on October 7 the gate was thrown wide open for one minute and then closed to the usual point.

A record of the daily (excepting Sundays and on certain other days) bacterial analyses of the effluent will be found in the following table. It should be noted that, of the mixture of *Bacillus prodigiosus* which was applied to the filter in the ratio of 1 part of solution in 170,000 parts of applied water, a few cells occasionally appeared in the effluent.

*Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 43, 1895.*

| DAY.      | May.  | JUNE.           |                 | JULY.           |                 | AUGUST.         |                 | SEPTEMBER.      |                 | OCTOBER.        |                 | NOVEMBER.       |                 |
|-----------|-------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|           |       | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. |
| 1, . . .  | 4,760 | 36              | -               | 60              | 0               | 310             | 0               | -               | -               | 60              | 1               | 29              | 1               |
| 2, . . .  | 1,127 | -               | -               | 32              | 0               | 840             | 32              | -               | -               | -               | -               | -               | -               |
| 3, . . .  | 315   | 47              | -               | 86              | 0               | 240             | 3               | 30              | 3               | 4,090           | 0               | -               | -               |
| 4, . . .  | 274   | 38              | -               | -               | -               | -               | -               | 74              | 6               | -               | -               | 45              | 0               |
| 5, . . .  | -     | 30              | -               | 68              | 6               | 232             | 0               | 110             | 0               | 317             | 0               | -               | -               |
| 6, . . .  | 385   | 16              | -               | 60              | 0               | 120             | 0               | 70              | 0               | -               | -               | 27              | 0               |
| 7, . . .  | 234   | 90              | -               | -               | -               | 218             | 13              | -               | -               | 154             | 3               | -               | -               |
| 8, . . .  | 175   | 38              | -               | 182             | 1               | 102             | 8               | -               | -               | 163             | 1               | 145             | 0               |
| 9, . . .  | 150   | -               | -               | 74              | 3               | 66              | 2               | 60              | 1               | -               | -               | -               | -               |
| 10, . . . | 123   | 102             | 5               | 525             | 5               | 65              | 16              | 39              | 12              | -               | -               | -               | -               |
| 11, . . . | 135   | 34              | 6               | 139             | 0               | -               | -               | 35              | 6               | -               | -               | 110             | 0               |
| 12, . . . | -     | 92              | 0               | 360             | 0               | 45              | 11              | 46              | 0               | 504             | 0               | -               | -               |
| 13, . . . | 328   | 120             | 0               | 180             | 14              | 44              | 12              | -               | -               | -               | -               | 47              | 0               |
| 14, . . . | 90    | 148             | 0               | -               | -               | 32              | 6               | -               | -               | 510             | 0               | -               | -               |
| 15, . . . | 56    | 2,880           | 0               | 280             | 0               | 60              | 0               | -               | -               | 105             | 0               | 78              | 0               |
| 16, . . . | 14    | -               | -               | 120             | 0               | 33              | 4               | 3               | 0               | -               | -               | -               | -               |
| 17, . . . | 41    | 91              | 0               | 455             | 1               | 37              | 13              | 28              | 4               | 108             | 0               | -               | -               |
| 18, . . . | 21    | 73              | 0               | 120             | 0               | -               | -               | 480             | 7               | 68              | 0               | 70              | 0               |
| 19, . . . | -     | 480             | 0               | 92              | 23              | 42              | 4               | 735             | 7               | -               | -               | 157             | 0               |
| 20, . . . | 770   | 210             | 0               | 56              | 0               | 75              | 3               | 280             | 0               | -               | -               | -               | -               |
| 21, . . . | 35    | 161             | 0               | -               | -               | 41              | 5               | 126             | 0               | -               | -               | -               | -               |
| 22, . . . | 15    | 92              | 0               | 63              | 7               | 43              | 30              | -               | -               | 71              | 0               | -               | -               |
| 23, . . . | 54    | -               | -               | 47              | 0               | 58              | 60              | 155             | 4               | 30              | 0               | 122             | 0               |
| 24, . . . | 54    | 120             | 0               | 58              | 0               | 53              | 2               | 51              | 0               | -               | -               | -               | -               |
| 25, . . . | 31    | 140             | 9               | 85              | 0               | -               | -               | -               | -               | -               | -               | -               | -               |
| 26, . . . | -     | 270             | 0               | 30              | 5               | 72              | 8               | 158             | 0               | -               | -               | -               | -               |
| 27, . . . | 60    | 190             | 20              | 21              | 3               | -               | -               | -               | -               | -               | -               | -               | -               |
| 28, . . . | 75    | 285             | 14              | -               | -               | 38              | 0               | 95              | 0               | 46              | 2               | -               | -               |
| 29, . . . | 21    | 2,380           | 0               | 38              | 0               | 27              | 3               | -               | -               | -               | -               | -               | -               |
| 30, . . . | 35    | -               | -               | 27              | 0               | 35              | 6               | -               | -               | 48              | 0               | -               | -               |
| 31, . . . | 10    | -               | -               | 38              | 0               | 24              | 0               | -               | -               | -               | -               | -               | -               |

*Monthly Averages of Analyses of Effluent of Filter No. 43.*

[Parts per 100,000.]

| 1895.        | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | Bacteria per Cubic Centimeter. |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |                                |
| May, . . .   | 4,960,000                                        | 61                      | 63        | .40    | .0005    | .0096       | .17       | .0230       | .0000     | .36              | 39                             | 144                            |
| June, . . .  | 4,760,000                                        | 71                      | 71        | .33    | .0009    | .0094       | .19       | .0230       | .0001     | .33              | 14                             | 92                             |
| July, . . .  | 4,740,000                                        | 72                      | 71        | .29    | .0019    | .0100       | .29       | .0260       | .0013     | .32              | 6                              | 65                             |
| August, . .  | 4,860,000                                        | 73                      | 74        | .22    | .0019    | .0117       | .30       | .0260       | .0004     | .25              | 11                             | 77                             |
| September, . | 4,660,000                                        | 71                      | 71        | .19    | .0018    | .0078       | .30       | .0340       | .0008     | .19              | 5                              | 49                             |
| October, . . | 4,760,000                                        | 51                      | 54        | .45    | .0011    | .0137       | .23       | .0260       | .0000     | .52              | 25                             | 107                            |
| November, .  | 4,700,000                                        | 44                      | 45        | .62    | .0019    | .0136       | .20       | .0200       | .0000     | .55              | 82                             | 92                             |

*Filter No. 44.*

This continuous filter was started May 20, 1893, and contained 60 inches in depth of sand of an effective size of 0.29 millimeter. The history of this filter up to Dec. 31, 1894, has been published in previous reports of the Board. Its history during 1895 contains the following principal points:—

From Dec. 1, 1894, to April 30, 1895, the filter was not operated. On May 1, 1895, with a depth of sand equal to 52 inches, after having been filled slowly from below with city water, filtration of canal water was begun at a prescribed rate of 7,000,000 gallons per acre daily. A short trap attached to the outlet prevented air from entering at that point. Owing to low water in the canal the gate on the outlet remained closed and the surface of the sand covered with water on May 5, 18, June 8, July 6, 13, and August 3, for periods varying from seven to thirty-nine hours. In order to remove clogging, the surface was scraped as follows: May 25, 0.40 inch of sand was removed; June 12, 0.31 inch; June 29, 0.48 inch; June 22, 0.22 inch; July 5, 1.06 inches; July 16, 0.36 inch; July 22, 0.26 inch; July 26, 0.44 inch; July 31, 0.34 inch; on August 1, enough sand was removed to reduce the depth of filtering material to 36 inches; on August 21, 0.40 inch; on August 28, 0.45 inch. The surface was not raked after scraping and the filter was filled usually with canal water from above, but on July 31 city (filtered) water was applied below until the surface of the sand was covered with water before canal water was applied.



*Bacillus prodigiosus* mixture was applied to this filter from July 9 to 22 in the proportion of 1 part solution in 170,000 parts of applied water. A record of the daily (excepting Sundays and certain other days) bacterial analyses of the effluent will be found in the following table:—

*Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter  
No. 44, 1895.*

| DAY.          | May.  | JUNE.              |                      | July. | August. |
|---------------|-------|--------------------|----------------------|-------|---------|
|               |       | Water<br>Bacteria. | B. Prodig-<br>iosus. |       |         |
| 1, . . . . .  | 3,570 | 24                 | -                    | 63    | 110     |
| 2, . . . . .  | 315   | -                  | -                    | 38    | 250     |
| 3, . . . . .  | 280   | 26                 | -                    | 31    | 160     |
| 4, . . . . .  | 240   | 20                 | -                    | -     | -       |
| 5, . . . . .  | -     | 35                 | -                    | 38    | 104     |
| 6, . . . . .  | 364   | 23                 | -                    | 50    | 45      |
| 7, . . . . .  | 96    | 34                 | -                    | -     | 84      |
| 8, . . . . .  | 92    | 17                 | -                    | 48    | 39      |
| 9, . . . . .  | 95    | -                  | -                    | 42    | 39      |
| 10, . . . . . | 130   | 65                 | 0                    | 50    | 23      |
| 11, . . . . . | 107   | 40                 | 0                    | 98    | -       |
| 12, . . . . . | -     | 32                 | 0                    | 114   | 21      |
| 13, . . . . . | 79    | 70                 | 0                    | 128   | 18      |
| 14, . . . . . | 60    | 75                 | 0                    | -     | 65      |
| 15, . . . . . | 36    | 55                 | 0                    | 110   | 45      |
| 16, . . . . . | 36    | -                  | 0                    | 94    | 29      |
| 17, . . . . . | 70    | 38                 | 0                    | 350   | 17      |
| 18, . . . . . | 86    | 38                 | 0                    | 52    | -       |
| 19, . . . . . | -     | 95                 | 0                    | 54    | 38      |
| 20, . . . . . | 350   | 53                 | 0                    | 35    | 30      |
| 21, . . . . . | 95    | 40                 | 0                    | -     | 27      |
| 22, . . . . . | 72    | 88                 | 0                    | 41    | 31      |
| 23, . . . . . | 85    | -                  | -                    | 19    | 22      |
| 24, . . . . . | 262   | 72                 | -                    | 24    | 31      |
| 25, . . . . . | 33    | 90                 | -                    | 60    | -       |
| 26, . . . . . | -     | 180                | -                    | 49    | 38      |
| 27, . . . . . | 27    | 86                 | -                    | 49    | -       |
| 28, . . . . . | 41    | 74                 | -                    | -     | 41      |
| 29, . . . . . | 45    | 122                | -                    | 26    | 38      |
| 30, . . . . . | 23    | -                  | -                    | 20    | -       |
| 31, . . . . . | 65    | -                  | -                    | 110   | -       |

*Monthly Averages of Analyses of Effluent of Filter No. 44.*

[Parts per 100,000.]

| 1895.       | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |          | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | Bacteria per Cubic Centimeter. |
|-------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|----------|------------------|--------------------------------|--------------------------------|
|             |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrate.    | Nitrite. |                  |                                |                                |
| May, . . .  | 6,820,000                                        | 61                      | 64        | .44    | .0005    | .0093       | .17       | .0190       | .0000    | .37              | 43                             | 179                            |
| June, . . . | 6,880,000                                        | 71                      | 71        | .30    | .0008    | .0086       | .21       | .0310       | .0009    | .32              | 14                             | 37                             |
| July, . . . | 6,960,000                                        | 72                      | 69        | .27    | .0003    | .0087       | .26       | .0330       | .0000    | .29              | 27                             | 45                             |
| August, . . | 7,160,000                                        | 73                      | 74        | .23    | .0004    | .0096       | .30       | .0290       | .0003    | .24              | 10                             | 39                             |

*Filter No. 45.*

This intermittent filter was started July 10, 1893, and contained 60 inches in depth of sand of an effective size of 0.23 millimeter. The history of this filter up to Dec. 31, 1894, has been published in previous reports of the Board. Its history during 1895 contains the following principal points:—

From Dec. 1, 1894, to April 30, 1895, the filter was not in operation. On May 1, 1895, with a depth of sand of 57 inches, after having been filled with city (filtered) water from below, the filter began to filter canal water at a prescribed rate of 5,000,000 gallons per acre daily. The period of intermittent operation was arranged in such a manner that the surface of the sand remained uncovered for two hours during the day, excepting on Sundays, when the filter ran continuously. A trap attached to the outlet prevented air from entering at that point. On May 25 a stoppage in the pipe cut off the applied water, and the surface remained uncovered for twenty-seven hours. Owing to low water in the canal the gate on the outlet remained closed and the surface of the sand covered with water on the following dates: May 5, June 8, July 6, 13, August 3, September 22 and 28, for periods varying from twenty-four to thirty-nine hours. In order to remove clogging the surface was scraped as follows: on May 29, 0.36 inch of sand was removed; June 14, 0.42 inch; June 25, 0.52 inch; July 5, 0.46 inch; July 22, 0.36 inch; July 29, 0.32 inch; on August 1, enough sand was removed to reduce the filtering material to 36 inches; August 30, 0.60 inch; September 20, 0.60 inch; October 15, 0.54 inch; November 1, 0.42 inch; November 19, 0.44 inch. The surface was not raked after scraping, and the filter was filled immediately with canal water from above.

The rate of filtration was fluctuated as follows: on October 4 the gate on the outlet was closed for one minute and then opened to the usual point; on November 12 the gate was opened a little wider than usual, and on November 22 the gate was thrown wide open for one minute and then closed to the usual point.

*Bacillus prodigiosus* mixture was applied to this filter from June 22 until November 22, in the ratio of 1 part to 170,000 parts of applied canal water. The following table contains a record of the daily (excepting Sundays and on certain other occasions) bacterial analyses of the effluent from this filter:—

*Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 45, 1895.*

| DAY.      | May.  | JUNE.           |                 | JULY.           |                 | AUGUST.         |                 | SEPTEMBER.      |                 | OCTOBER.        |                 | NOVEMBER.       |                 |
|-----------|-------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|           |       | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. |
| 1, . . .  | 1,505 | 28              | -               | 14              | 0               | 560             | 0               | -               | -               | 57              | 8               | 46              | 1               |
| 2, . . .  | 525   | -               | -               | 140             | 1               | 1,140           | 0               | -               | -               | -               | -               | -               | -               |
| 3, . . .  | 160   | 32              | -               | 5               | 0               | 283             | 14              | 24              | 0               | 2,170           | 0               | -               | -               |
| 4, . . .  | 152   | 36              | -               | -               | -               | -               | -               | 34              | 0               | 4,400           | 0               | 75              | 3               |
| 5, . . .  | -     | 52              | -               | 7               | 0               | 82              | 9               | 50              | 0               | 1,029           | 0               | -               | -               |
| 6, . . .  | 38    | 20              | -               | 24              | 0               | 87              | 0               | 64              | 10              | -               | -               | 30              | 0               |
| 7, . . .  | 62    | 112             | -               | -               | -               | 135             | 0               | -               | -               | 326             | 1               | -               | -               |
| 8, . . .  | 23    | 16              | -               | 14              | 0               | 122             | 0               | -               | -               | 210             | 0               | 54              | 7               |
| 9, . . .  | 44    | -               | -               | 45              | 0               | 57              | 3               | 35              | 5               | -               | -               | -               | -               |
| 10, . . . | 32    | 20              | -               | 27              | 0               | 32              | 10              | 27              | 0               | -               | -               | -               | -               |
| 11, . . . | 30    | 30              | -               | 18              | 0               | -               | -               | 21              | 0               | -               | -               | 52              | 0               |
| 12, . . . | -     | 26              | -               | 43              | 0               | -               | -               | 10              | 0               | 325             | 7               | 75              | 1               |
| 13, . . . | 37    | 50              | -               | 118             | 0               | 46              | 0               | -               | -               | -               | -               | 87              | 0               |
| 14, . . . | 30    | 340             | -               | -               | -               | 23              | 0               | -               | -               | -               | -               | -               | -               |
| 15, . . . | 25    | 148             | -               | 54              | 0               | 42              | 0               | -               | -               | 990             | 0               | 280             | 2               |
| 16, . . . | 57    | -               | -               | 24              | 0               | 18              | 0               | 9               | 0               | -               | -               | -               | -               |
| 17, . . . | 16    | 27              | -               | 43              | 0               | 22              | 0               | 14              | 0               | 163             | 0               | -               | -               |
| 18, . . . | 12    | 23              | -               | 64              | 0               | -               | -               | 12              | 0               | 195             | 7               | 65              | 0               |
| 19, . . . | -     | 140             | -               | 24              | 0               | 36              | 0               | 70              | 0               | -               | -               | 114             | 3               |
| 20, . . . | 10    | 36              | -               | 70              | 0               | 4               | 0               | 520             | 27              | -               | -               | -               | -               |
| 21, . . . | 21    | 24              | -               | -               | -               | 25              | 0               | 475             | 3               | -               | -               | -               | -               |
| 22, . . . | 21    | 40              | -               | 65              | 2               | 30              | 0               | -               | -               | 125             | 7               | -               | -               |
| 23, . . . | 12    | -               | -               | 22              | 0               | 19              | 0               | 180             | 0               | 43              | 0               | 92              | 2               |
| 24, . . . | 37    | 8               | 0               | 9               | 0               | 26              | 0               | 80              | 2               | -               | -               | -               | -               |
| 25, . . . | 1,309 | 57              | 4               | 14              | 0               | -               | -               | -               | -               | 56              | 0               | -               | -               |
| 26, . . . | -     | 31              | 0               | 14              | 0               | 12              | 0               | 104             | 4               | -               | -               | -               | -               |
| 27, . . . | 2,580 | 24              | 0               | 21              | 0               | -               | -               | -               | -               | -               | -               | -               | -               |
| 28, . . . | 2,450 | 25              | 0               | -               | -               | 8               | 0               | 162             | 1               | 83              | 1               | -               | -               |
| 29, . . . | 840   | 9               | 0               | 30              | 0               | 16              | 0               | -               | -               | -               | -               | -               | -               |
| 30, . . . | 72    | -               | -               | 21              | 0               | 114             | 1               | -               | -               | 13              | 0               | -               | -               |
| 31, . . . | 47    | -               | -               | 10              | 0               | 58              | 11              | -               | -               | -               | -               | -               | -               |

*Monthly Averages of Analyses of Effluent of Filter No. 45.*

[Parts per 100,000.]

| 1895.        | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen | Bacteria per Cubic Centimeter. |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|----------------|-----------|------------------|-------------------------------|--------------------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.      | Nitrites. |                  |                               |                                |
| May, . . .   | 4,800,000                                        | 61                      | 63        | .38    | .0006    | .0091       | .17       | .0270          | .0000     | .34              | -                             | 50                             |
| June, . . .  | 4,460,000                                        | 71                      | 72        | .30    | .0005    | .0077       | .18       | .0340          | .0000     | .31              | 58                            | 32                             |
| July, . . .  | 4,280,000                                        | 72                      | 69        | .27    | .0005    | .0088       | .26       | .0330          | .0000     | .28              | 47                            | 36                             |
| August, . .  | 4,760,000                                        | 73                      | 72        | .21    | .0003    | .0103       | .30       | .0280          | .0000     | .24              | 32                            | 53                             |
| September, . | 4,680,000                                        | 71                      | 71        | .19    | .0004    | .0089       | .30       | .0320          | .0000     | .18              | 39                            | 45                             |
| October, . . | 4,020,000                                        | 51                      | 53        | .45    | .0011    | .0139       | .23       | .0270          | .0000     | .50              | 57                            | 127                            |
| November, .  | 3,780,000                                        | 44                      | 44        | .58    | .0010    | .0132       | .20       | .0270          | .0000     | .57              | 60                            | 72                             |

*Filter No. 46.*

This continuous filter was started on Aug. 21, 1893, and contained 12 inches in depth of sand of an effective size of 0.29 millimeter. The history of the filter up to Dec. 31, 1894, has been published in previous reports of the Board. Its history during 1895 contains the following principal points:—

From Dec. 1, 1894, to April 30, 1895, the filter was not operated. On May 1, with a depth of sand of 10 inches, after having been filled slowly with city water from below, canal water was applied continuously at a prescribed rate of 5,000,000 gallons per acre daily. A trap attached to the outlet prevented air from entering at that point. Owing to low water in the canal the gates on the outlet remained closed and the surface of the sand covered with water on the following dates: June 8, July 6, 13, and August 3, for periods varying from thirty-three to thirty-nine hours. In order to remove clogging the surface was scraped as follows: on May 23, 0.57 inch of sand was removed; on June 4, 0.48 inch; on June 17, 0.32 inch; on June 22, 0.38 inch; on June 26, 0.43 inch; on July 2, 0.39 inch; on July 10, 0.35 inch; on July 20, 0.47 inch; on July 26, 0.35 inch; on July 31, 0.35 inch; on August 6, 0.35 inch; on August 13, 0.41 inch; on August 21, 0.38 inch; on August 29, 0.49 inch. After scraping, the filter was not raked, but canal water was applied immediately from above. A record of daily (excepting Sundays and on a few other occasions) bacteria analyses will be found in the following table:—

*Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter  
No. 46, 1895.*

| DAY.          | May.  | June. | July. | August. |
|---------------|-------|-------|-------|---------|
| 1, . . . . .  | 2,170 | 50    | 34    | 64      |
| 2, . . . . .  | 665   | -     | 52    | 145     |
| 3, . . . . .  | 350   | 55    | 95    | 62      |
| 4, . . . . .  | 250   | 120   | -     | -       |
| 5, . . . . .  | -     | 62    | 96    | 130     |
| 6, . . . . .  | 187   | 58    | 60    | 78      |
| 7, . . . . .  | 162   | 50    | -     | 235     |
| 8, . . . . .  | 139   | 52    | 138   | 90      |
| 9, . . . . .  | 72    | -     | 113   | 61      |
| 10, . . . . . | 54    | 155   | 500   | 59      |
| 11, . . . . . | 95    | 43    | 240   | -       |
| 12, . . . . . | -     | 95    | 285   | 27      |
| 13, . . . . . | 62    | 180   | 325   | 65      |
| 14, . . . . . | 92    | 127   | -     | 116     |
| 15, . . . . . | 40    | 89    | 240   | 74      |
| 16, . . . . . | 85    | -     | 225   | 30      |
| 17, . . . . . | 31    | 258   | 511   | 19      |
| 18, . . . . . | 24    | 160   | 125   | -       |
| 19, . . . . . | -     | 210   | 110   | 35      |
| 20, . . . . . | 35    | 228   | 60    | 37      |
| 21, . . . . . | 34    | 105   | -     | 1,330   |
| 22, . . . . . | 44    | 642   | 38    | 302     |
| 23, . . . . . | 60    | -     | 42    | 296     |
| 24, . . . . . | 30    | 103   | 114   | 224     |
| 25, . . . . . | 25    | 66    | 49    | -       |
| 26, . . . . . | -     | 130   | 42    | 38      |
| 27, . . . . . | 80    | 95    | 68    | -       |
| 28, . . . . . | 24    | 170   | -     | 176     |
| 29, . . . . . | 110   | 71    | 64    | 150     |
| 30, . . . . . | 50    | -     | 38    | -       |
| 31, . . . . . | 60    | -     | 228   | -       |

*Monthly Averages of Analyses of Effluent of Filter No. 46.*

[Parts per 100,000.]

| 1895.         | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | Bacteria per Cubic Centimeter. |
|---------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|
|               |                                                  | Applied Water.          | Effluent. |        | Free.    | Albaminoid. |           | Nitrates.   | Nitrites. |                  |                                |                                |
| May, . . .    | 5,080,000                                        | 61                      | 60        | .40    | .0005    | .0096       | .17       | .0200       | .0000     | .43              | 63                             | 96                             |
| June, . . .   | 4,620,000                                        | 71                      | 71        | .32    | .0003    | .0094       | .21       | .0260       | .0000     | .35              | 24                             | 78                             |
| July, . . .   | 4,660,000                                        | 72                      | 70        | .29    | .0005    | .0090       | .26       | .0280       | .0000     | .32              | 26                             | 106                            |
| August, . . . | 4,620,000                                        | 73                      | 74        | .22    | .0011    | .0117       | .30       | .0280       | .0000     | .25              | 4                              | 54                             |

*Filter No. 47.*

This intermittent filter was started Sept. 9, 1893, and contained 60 inches in depth of sand of an effective size of 0.29 millimeter. Its history up to Dec. 31, 1894, has been published in previous reports of the Board. The history of the filter during 1895 contains the following principal points:—

From Dec. 1, 1894, to April 30, 1895, the filter was not in operation. On May 1, 1895, with a depth of sand of 51 inches, after having been filled slowly from below with city water, filtration of canal water was begun at a rate of 7,000,000 gallons per acre daily. The period of intermittent operation was arranged in such a manner that the surface remained uncovered for two hours during the day. A trap attached to the outlet of the filter prevented air from entering at that point. Owing to low water in the canal the gate on the outlet remained closed on the following dates: June 8, July 6, 13 and August 3, for periods varying from thirty-three to thirty-nine hours. In order to remove clogging the surface was scraped as follows: on May 17, 0.30 inch of sand was removed; on May 30, 0.45 inch; June 8, 0.35 inch; June 19, 0.30 inch; June 21, 0.44 inch; June 25, 0.37 inch; on June 29, 0.32 inch; July 2, 0.31 inch; July 6, 0.30 inch; July 11, 0.28 inch; July 17, 0.29 inch; July 24, 0.37 inch; July 27, 0.24 inch; on August 1 the filtering material was reduced to 36 inches in depth; August 16, 0.34 inch; August 27, 0.48 inch. After scraping, the surface was not raked, but canal water was applied immediately from above. On July 29 the filter

was filled with city water from below. A record of the daily (excepting Sundays and on certain other occasions) bacterial analyses will be found in the following table:—

*Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter  
No. 47, 1895.*

| DAY.          | May.  | June. | July. | August. |
|---------------|-------|-------|-------|---------|
| 1, . . . . .  | 3,570 | 52    | 44    | 450     |
| 2, . . . . .  | 450   | -     | 31    | 221     |
| 3, . . . . .  | 868   | 19    | 48    | 148     |
| 4, . . . . .  | 350   | 44    | -     | -       |
| 5, . . . . .  | -     | 24    | 43    | 97      |
| 6, . . . . .  | 124   | 22    | 68    | 57      |
| 7, . . . . .  | 143   | 35    | -     | 52      |
| 8, . . . . .  | 106   | 60    | 23    | 38      |
| 9, . . . . .  | 101   | -     | 16    | 28      |
| 10, . . . . . | 123   | 70    | 80    | 25      |
| 11, . . . . . | 89    | 10    | 120   | -       |
| 12, . . . . . | -     | 14    | 95    | 18      |
| 13, . . . . . | 60    | 112   | 120   | 35      |
| 14, . . . . . | 83    | 64    | -     | 40      |
| 15, . . . . . | 180   | 82    | 75    | 23      |
| 16, . . . . . | 42    | -     | 45    | 17      |
| 17, . . . . . | 70    | 75    | 390   | 25      |
| 18, . . . . . | 48    | 49    | 135   | -       |
| 19, . . . . . | -     | 110   | 91    | 14      |
| 20, . . . . . | 60    | 57    | 71    | 14      |
| 21, . . . . . | 36    | 68    | -     | 13      |
| 22, . . . . . | 41    | 140   | 34    | 44      |
| 23, . . . . . | 34    | -     | 55    | 27      |
| 24, . . . . . | 24    | 37    | 32    | 54      |
| 25, . . . . . | 67    | 31    | 41    | -       |
| 26, . . . . . | -     | 61    | 35    | 31      |
| 27, . . . . . | 34    | 74    | 13    | -       |
| 28, . . . . . | 23    | 43    | -     | 40      |
| 29, . . . . . | 15    | 82    | 22    | 46      |
| 30, . . . . . | 35    | -     | 55    | 55      |
| 31, . . . . . | 30    | -     | 29    | -       |

*Monthly Averages of Analyses of Effluent of Filter No. 47.*

[Parts per 100,000.]

| 1895.         | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | Bacteria per Cubic Centimeter. |
|---------------|--------------------------------------------------|-------------------------|-----------|--------|----------|---------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|
|               |                                                  | Applied Water.          | Effluent. |        | Free.    | Alb.-minhold. |           | Nitrates.   | Nitrites. |                  |                                |                                |
| May, . . .    | 7,020,000                                        | 61                      | 64        | .41    | .0003    | .0097         | .17       | .0220       | .0000     | .39              | 71                             | 84                             |
| June, . . .   | 6,160,000                                        | 71                      | 71        | .32    | .0004    | .0038         | .21       | .0260       | .0000     | .34              | 44                             | 52                             |
| July, . . .   | 6,260,000                                        | 72                      | 72        | .27    | .0007    | .0090         | .29       | .0480       | .0000     | .28              | 48                             | 57                             |
| August, . . . | 6,760,000                                        | 73                      | 73        | .23    | .0008    | .0112         | .30       | .0280       | .0000     | .25              | 19                             | 37                             |

*Filter No. 48.*

This continuous filter was started Sept. 9, 1893, and contained 60 inches in depth of sand of an effective size of 0.38 millimeter. The history of this filter up to Dec. 31, 1894, has been published in previous reports of the Board. Its history during 1895 contains the following principal points:—

From Dec. 1, 1894, to May 15, 1895, the filter was not in operation. On May 16, 1895, it was filled slowly with city water from below. On May 17, with a depth of sand equal to 51 inches, it began to filter city (filtered) water continuously at a rate of 5,000,000 gallons per acre daily. On June 17 the city water was shut off and canal water applied from that date until November 23, when the canal water was shut off and city (filtered) water again applied for one week. A trap attached to the outlet prevented air from entering the filter at that point. Owing to low water in the canal the gate on the outlet remained closed, and the surface of the sand covered with water on the following dates: June 8, July 6, 13, August 3, September 22 and 28, for periods varying from twenty-four to forty hours. In order to remove clogging the surface of the sand was scraped as follows: July 17, 0.57 inch of sand was removed; August 9, 0.38 inch; August 21, 0.40 inch; September 4, 0.45 inch; September 16, 0.39 inch; September 28, 0.40 inch; October 15, 0.44 inch; October 30, 0.68 inch; November 13, 0.37 inch; November 19, 0.26 inch. After scraping, the surface was not raked, and canal water was applied at the top immediately. November 13 the surface was dug over 6 inches deep, after scraping, and on November 19, city (filtered) water was applied slowly from below until the surface of the sand was covered with water.



The rate of filtration was fluctuated as follows : on September 14 the gate on the outlet was closed for one minute and then opened to the usual point ; on October 9 the gate was thrown wide open, and on October 16, 21, 26, the gate was opened a little wider than usual for one minute and then closed to the usual point.

In order to test the bacterial efficiency of the filter a solution seeded with *Bacillus prodigiosus* was mixed with the applied canal water in the ratio of 1 part to 170,000 parts, for ten hours a day, from June 10 to November 23. A record of the daily (excepting Sundays and on certain other occasions) bacterial analyses will be found in the following table :—

*Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 48, 1895.*

| DAY.      | May.  | JUNE.           |                 | JULY.           |                 | AUGUST.         |                 | SEPTEMBER.      |                 | OCTOBER.        |                 | NOVEMBER.       |                 |
|-----------|-------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|           |       | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. |
| 1, . . .  | -     | 86              | -               | 31              | 0               | 75              | 0               | -               | -               | 56              | 1               | 11              | 0               |
| 2, . . .  | -     | -               | -               | 24              | 2               | 44              | 0               | -               | -               | -               | -               | -               | -               |
| 3, . . .  | -     | 20              | -               | 25              | 0               | 46              | 0               | 54              | 34              | 1,750           | 0               | -               | -               |
| 4, . . .  | -     | 26              | -               | -               | -               | -               | -               | 41              | 0               | -               | -               | 9               | 0               |
| 5, . . .  | -     | 126             | -               | 48              | 0               | 114             | 0               | 62              | 0               | 180             | 0               | -               | -               |
| 6, . . .  | -     | 32              | -               | 51              | 0               | 46              | 0               | 43              | 4               | -               | -               | 11              | 0               |
| 7, . . .  | -     | 45              | -               | -               | -               | 69              | 0               | -               | -               | 21              | 27              | -               | -               |
| 8, . . .  | -     | 39              | -               | 125             | 1               | 41              | 0               | -               | -               | 116             | 1               | 106             | 0               |
| 9, . . .  | -     | -               | -               | 50              | 0               | 75              | 0               | 42              | 0               | 350             | 0               | -               | -               |
| 10, . . . | -     | 95              | 0               | 120             | 0               | 46              | 0               | 37              | 0               | -               | -               | -               | -               |
| 11, . . . | -     | 83              | 0               | 118             | 0               | -               | -               | 30              | 0               | -               | -               | 26              | 0               |
| 12, . . . | -     | 24              | 0               | 144             | 0               | 54              | 0               | 32              | 0               | 245             | 0               | -               | -               |
| 13, . . . | -     | 24              | 1               | 102             | 0               | 70              | 0               | -               | -               | -               | -               | 145             | 0               |
| 14, . . . | -     | 320             | 0               | -               | -               | 21              | 0               | 10              | 0               | 71              | 0               | -               | -               |
| 15, . . . | -     | 120             | 0               | 390             | 2               | 29              | 0               | -               | -               | 140             | 0               | 114             | 0               |
| 16, . . . | -     | -               | -               | 55              | 0               | 22              | 0               | 28              | 0               | -               | -               | -               | -               |
| 17, . . . | 2,394 | 72              | 0               | 372             | 0               | 51              | 0               | 18              | 0               | 82              | 0               | -               | -               |
| 18, . . . | 900   | 131             | 0               | 195             | 0               | -               | -               | 132             | 1               | 66              | 0               | 95              | 0               |
| 19, . . . | -     | 127             | 0               | 127             | 0               | 20              | 1               | 185             | 0               | -               | -               | 98              | 0               |
| 20, . . . | 1,260 | 112             | 0               | 30              | 0               | 45              | 0               | 89              | 0               | -               | -               | -               | -               |
| 21, . . . | 420   | 170             | 0               | -               | -               | 250             | 0               | 48              | 1               | 32              | 0               | -               | -               |
| 22, . . . | 476   | 112             | 0               | 35              | 0               | 116             | 0               | -               | -               | 40              | 1               | -               | -               |
| 23, . . . | 595   | -               | -               | 38              | 0               | 54              | 0               | 146             | 1               | 18              | 0               | 111             | 2               |
| 24, . . . | 770   | 94              | 0               | 20              | 0               | 52              | 0               | 78              | 0               | -               | -               | -               | -               |
| 25, . . . | 406   | 540             | 0               | 70              | 1               | -               | -               | -               | -               | 42              | 0               | -               | -               |
| 26, . . . | -     | 126             | 0               | 35              | 0               | 15              | 0               | 106             | 0               | -               | -               | -               | -               |
| 27, . . . | 42    | 56              | 0               | 38              | 0               | -               | -               | 65              | 0               | -               | -               | -               | -               |
| 28, . . . | 132   | 102             | 0               | -               | -               | 39              | 0               | 65              | 0               | 33              | 0               | -               | -               |
| 29, . . . | 116   | 71              | 0               | 34              | 0               | 31              | 0               | -               | -               | -               | -               | -               | -               |
| 30, . . . | 125   | -               | -               | 44              | 0               | 20              | 5               | -               | -               | 78              | 0               | -               | -               |
| 31, . . . | 97    | -               | -               | 25              | 0               | 18              | -               | -               | -               | -               | -               | -               | -               |

*Monthly Averages of Analyses of Effluent of Filter No. 48.*

[Parts per 100,000.]

| 1895.        | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN<br>as |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | Bacteria per Cubic Centimeter. |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|----------------|-----------|------------------|--------------------------------|--------------------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.      | Nitrites. |                  |                                |                                |
|              |                                                  |                         |           |        |          |             |           |                |           |                  |                                |                                |
| May, . . .   | 4,420,000                                        | 61                      | 56        | .31    | .0002    | .0076       | .21       | .0480          | .0000     | .25              | 77                             | 770                            |
| June, . . .  | 4,800,000                                        | 71                      | 67        | .25    | .0005    | .0077       | .24       | .0380          | .0000     | .27              | 42                             | 164                            |
| July, . . .  | 4,780,000                                        | 72                      | 69        | .30    | .0004    | .0096       | .26       | .0320          | .0000     | .30              | 22                             | 122                            |
| August, . .  | 4,760,000                                        | 73                      | 74        | .22    | .0042    | .0099       | .30       | .0290          | .0013     | .26              | 4                              | 84                             |
| September, . | 4,620,000                                        | 71                      | 70        | .19    | .0017    | .0088       | .30       | .0300          | .0009     | .19              | 1                              | 55                             |
| October, . . | 4,900,000                                        | 51                      | 53        | .44    | .0011    | .0130       | .23       | .0260          | .0000     | .52              | 20                             | 64                             |
| November, .  | 4,760,000                                        | 44                      | 46        | .52    | .0018    | .0134       | .22       | .0200          | .0000     | .63              | 108                            | 11                             |

*Filter No. 49.*

This continuous filter was started Sept. 9, 1893, and contained 60 inches in depth of sand of an effective size of 0.38 millimeter. The history of the filter up to Dec. 31, 1894, has been published in previous reports of the Board. Its history during 1895 contains the following principal points:—

From Dec. 1, 1894, to May 15, 1895, the filter was not in operation. On May 16, 1895, it was filled slowly from below with city (filtered) water and allowed to stand over night. On May 17, with 56 inches in depth of sand it began to filter city (filtered) water continuously at a rate of 10,000,000 gallons per acre daily. June 17 the city water was shut off and canal water applied regularly until November 23, when the city water was turned on again for one week. A short trap attached to the outlet prevented air from entering at this point. The surface of the sand became uncovered on May 21, therefore the filter was filled from above, the gates closed and the filter allowed to rest for fourteen hours. On account of low water in the canal the gate on the outlet remained closed and the surface of the sand covered with water on the following dates: June 8, July 6, 13, August 3, September 22 and 28, for periods varying from twenty-four to forty hours. In order to remove clogging the surface of the filter was scraped as follows: on June 30, 0.45 inch of sand was removed; July 13, 0.52 inch; July 22, 0.44 inch; July 27, 0.38 inch; July 30, 0.41 inch; August 3, 0.47 inch; August 9, 0.54 inch; August 14, 0.39 inch; August 21, 0.34 inch; August 23, 0.37 inch; September 5, 0.44 inch; September 9, 0.47 inch; September 12, 0.68 inch; September

25, 0.42 inch; September 30, 0.32 inch; October 9, 0.48 inch; October 11, 0.20 inch; October 15, 0.27 inch; October 24, 0.58 inch; October 30, 0.68 inch; November 2, 0.63 inch; November 5, 0.68 inch; November 9, 0.24 inch; and November 19, 0.30 inch. After scraping, the filter was not raked, and canal water was applied above immediately. On November 9 the surface was dug over 6 inches, and on November 18, after filling from above with canal water, the filter stood for an hour, after scraping, before being put into operation.

The rate of filtration was fluctuated as follows: on September 14 the gate was opened a little wider than usual, and on October 21 the gate was thrown wide open for one minute and then closed to the usual point. A solution seeded with *B. prodigiosus* was applied, as in the case of Filter No. 48.

A record of the daily (excepting Sundays and on certain other occasions) bacterial analyses will be found in the following table:—

*Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 49, 1895.*

| DAY.          | May.  | JUNE.           |                 | JULY.           |                 | AUGUST.         |                 | SEPTEMBER.      |                 | OCTOBER.        |                 | NOVEMBER.       |                 |
|---------------|-------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               |       | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. |
| 1, . . . . .  | -     | 77              | -               | 64              | 0               | 38              | 0               | -               | -               | 37              | 6               | 25              | 0               |
| 2, . . . . .  | -     | -               | -               | 34              | 2               | 35              | 0               | -               | -               | -               | -               | 39              | 0               |
| 3, . . . . .  | -     | 51              | -               | 63              | 0               | 68              | 0               | 44              | 0               | 2,086           | 0               | -               | -               |
| 4, . . . . .  | -     | 40              | -               | -               | 0               | -               | -               | 50              | 12              | -               | -               | 29              | 0               |
| 5, . . . . .  | -     | 53              | -               | 45              | 0               | 75              | 0               | 44              | 0               | 171             | 1               | 36              | 2               |
| 6, . . . . .  | -     | 30              | -               | 42              | 0               | 40              | 0               | 82              | 20              | -               | -               | 21              | 0               |
| 7, . . . . .  | -     | 57              | -               | -               | 0               | 70              | 0               | -               | -               | 85              | 0               | -               | -               |
| 8, . . . . .  | -     | 57              | -               | 180             | 0               | 56              | 0               | -               | -               | 93              | 0               | 47              | 0               |
| 9, . . . . .  | -     | -               | -               | 56              | 12              | 52              | 0               | 35              | 3               | 1,050           | 40              | -               | -               |
| 10, . . . . . | -     | 75              | 0               | 185             | 1               | 38              | 9               | 41              | 0               | 390             | 6               | -               | -               |
| 11, . . . . . | -     | 36              | 0               | 122             | 0               | -               | -               | 24              | 4               | 104             | 2               | 36              | 0               |
| 12, . . . . . | -     | 39              | 0               | 128             | 0               | 24              | 0               | 31              | 0               | 4,753           | 12              | -               | -               |
| 13, . . . . . | -     | 62              | 0               | 504             | 0               | 85              | 9               | -               | -               | -               | -               | 30              | 0               |
| 14, . . . . . | -     | 38              | 0               | -               | -               | 28              | 3               | 27              | 18              | 148             | 1               | -               | -               |
| 15, . . . . . | -     | 44              | 0               | 310             | 0               | 27              | 13              | -               | -               | 152             | 0               | 14              | 0               |
| 16, . . . . . | -     | -               | -               | 70              | 0               | 26              | 0               | 15              | 10              | -               | -               | -               | -               |
| 17, . . . . . | 4,539 | 295             | 16              | 287             | 1               | 87              | 0               | 15              | 1               | 66              | 0               | -               | -               |
| 18, . . . . . | 1,015 | 289             | 5               | 74              | 8               | -               | -               | 88              | 1               | 125             | 0               | 21              | 0               |
| 19, . . . . . | -     | 240             | 10              | 97              | 4               | 32              | 0               | 185             | 0               | -               | -               | 85              | 0               |
| 20, . . . . . | 1,050 | 160             | 0               | 80              | 0               | 23              | 11              | 110             | 0               | -               | -               | -               | -               |
| 21, . . . . . | 560   | 163             | 10              | -               | -               | 87              | 2               | 62              | 0               | -               | -               | -               | -               |
| 22, . . . . . | 490   | 186             | 0               | 52              | 0               | 48              | 16              | -               | -               | 61              | 0               | -               | -               |
| 23, . . . . . | 448   | -               | 0               | 53              | 0               | 84              | 14              | 136             | 8               | 29              | 0               | 121             | 0               |
| 24, . . . . . | 780   | 82              | 0               | 42              | 0               | 260             | 0               | 90              | 0               | -               | -               | -               | -               |
| 25, . . . . . | 203   | 38              | 0               | 47              | 0               | -               | -               | -               | -               | 162             | 3               | -               | -               |
| 26, . . . . . | -     | 60              | 0               | 75              | 0               | 35              | 35              | 184             | 0               | -               | -               | -               | -               |
| 27, . . . . . | 120   | 59              | 0               | 45              | 0               | -               | -               | 60              | 11              | -               | -               | -               | -               |
| 28, . . . . . | 125   | 60              | 0               | -               | -               | 38              | 5               | 60              | 0               | 127             | 0               | -               | -               |
| 29, . . . . . | 102   | 78              | 0               | 52              | 0               | 60              | 0               | -               | -               | -               | -               | -               | -               |
| 30, . . . . . | 80    | -               | -               | 51              | 0               | 27              | 6               | -               | -               | 58              | 0               | -               | -               |
| 31, . . . . . | 55    | -               | -               | 39              | 0               | 15              | 0               | -               | -               | -               | -               | -               | -               |

*Monthly Averages of Analyses of Effluent of Filter No. 49.*

[Parts per 100,000.]

| 1895.        | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |               | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | Bacteria per Cubic Centimeter. |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|---------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Alb.-minhold. |           | Nitrates.   | Nitrites. |                  |                                |                                |
| May, . . .   | 9,980,000                                        | 61                      | 55        | .30    | .0002    | .0078         | .20       | .0480       | .0000     | .26              | 88                             | 780                            |
| June, . . .  | 9,380,000                                        | 71                      | 67        | .25    | .0004    | .0081         | .24       | .0340       | .0000     | .28              | 44                             | 148                            |
| July, . . .  | 9,260,000                                        | 72                      | 70        | .31    | .0009    | .0099         | .26       | .0310       | .0000     | .31              | 19                             | 60                             |
| August, . .  | 9,260,000                                        | 73                      | 74        | .22    | .0004    | .0095         | .30       | .0350       | .0003     | .26              | 05                             | 33                             |
| September, . | 9,080,000                                        | 71                      | 70        | .19    | .0013    | .0096         | .30       | .0350       | .0002     | .20              | 00                             | 60                             |
| October, . . | 9,540,000                                        | 51                      | 54        | .51    | .0013    | .0144         | .24       | .0260       | .0000     | .52              | 20                             | 61                             |
| November, .  | 7,280,000                                        | 44                      | 44        | .55    | .0032    | .0162         | .22       | .0210       | .0000     | .60              | 100                            | 21                             |

*Filter No. 50.*

This continuous filter was started July 23, 1894, and contained 60 inches in depth of sand of an effective size of 0.48 millimeter. The history of the filter up to Dec. 31, 1894, has been published in previous reports of the Board. Its history during 1895 contains the following principal points:—

From Dec. 1, 1894, to April 30, 1895, the filter was not in operation. On May 1, 1895, with a depth of 58 inches, after having been filled slowly from below with city water, this filter began to filter canal water continuously at a prescribed rate of 5,000,000 gallons per acre daily. A trap attached to the outlet of the filter prevented air from entering at that point. Owing to a stoppage in the feed-pipe on May 25, the surface of the sand became uncovered, and the filter was not in operation for twenty-six hours. On account of low water in the canal the gate on the outlet was closed, though the surface remained covered with water, on the following dates: June 8, July 6, 13, August 3, September 22 and 28, for periods varying from twenty-four to thirty-nine hours. In order to remove clogging the surface of the sand was scraped as follows: on June 18, 0.41 inch of sand was removed; on July 18, 0.47 inch; July 27, 0.47 inch; August 21, 0.63 inch; on August 31 enough sand was removed to reduce the depth of filtering material to 36 inches; October 15, 0.42 inch; November 7, 0.70 inch. After scraping, the filter was not raked, and canal water was applied above, except on October 15, when the filter was filled slowly with city water from

below. On October 7 the rate of filtration was fluctuated by closing the gate on the outlet for one minute and then opening the gate abruptly to the usual point. A record of the daily (excepting Sundays and on certain other occasions) bacterial analyses will be found in the following table:—

*Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 50, 1895.*

| DAY.          | May.  | June. | July. | August. | September. | October. | November. |
|---------------|-------|-------|-------|---------|------------|----------|-----------|
| 1, . . . . .  | 350   | 71    | 35    | 37      | -          | 30       | 21        |
| 2, . . . . .  | 1,190 | -     | 37    | 28      | -          | -        | -         |
| 3, . . . . .  | 434   | 85    | 16    | 30      | 110        | 2,646    | -         |
| 4, . . . . .  | 310   | 24    | -     | -       | 98         | -        | 16        |
| 5, . . . . .  | -     | 64    | 31    | 50      | 162        | 144      | -         |
| 6, . . . . .  | 455   | 45    | 50    | 39      | 58         | -        | 23        |
| 7, . . . . .  | 210   | 50    | -     | 55      | -          | 76       | -         |
| 8, . . . . .  | 108   | 45    | 52    | 30      | -          | 123      | 63        |
| 9, . . . . .  | 52    | -     | 54    | 27      | 32         | -        | -         |
| 10, . . . . . | 146   | 70    | 109   | 34      | 54         | -        | -         |
| 11, . . . . . | 135   | 53    | 87    | -       | 56         | -        | 27        |
| 12, . . . . . | -     | 34    | 97    | 50      | 47         | 350      | -         |
| 13, . . . . . | 91    | 88    | 151   | 75      | -          | -        | 31        |
| 14, . . . . . | 72    | 62    | -     | 31      | 6          | 116      | -         |
| 15, . . . . . | 76    | 62    | 130   | 35      | -          | 420      | 14        |
| 16, . . . . . | 56    | -     | 102   | 29      | 9          | -        | -         |
| 17, . . . . . | 74    | 42    | 97    | 18      | 20         | 160      | -         |
| 18, . . . . . | 43    | 46    | 90    | -       | 31         | 135      | 45        |
| 19, . . . . . | -     | 430   | 85    | 67      | 90         | -        | 60        |
| 20, . . . . . | 110   | 84    | 53    | 32      | 75         | -        | -         |
| 21, . . . . . | 30    | 78    | -     | 31      | 42         | -        | -         |
| 22, . . . . . | 70    | 73    | 21    | 27      | -          | 71       | -         |
| 23, . . . . . | 93    | -     | 57    | 50      | 170        | 52       | 112       |
| 24, . . . . . | 72    | 85    | 35    | 88      | 41         | -        | -         |
| 25, . . . . . | 97    | 37    | 52    | -       | -          | 130      | -         |
| 26, . . . . . | -     | 106   | 14    | 15      | 57         | -        | -         |
| 27, . . . . . | 122   | 174   | 24    | -       | -          | -        | -         |
| 28, . . . . . | 55    | 85    | -     | 60      | 52         | 35       | -         |
| 29, . . . . . | 40    | 70    | 30    | 37      | -          | -        | -         |
| 30, . . . . . | 56    | -     | 42    | 18      | -          | 45       | -         |
| 31, . . . . . | 47    | -     | 52    | -       | -          | -        | -         |

*Monthly Averages of Analyses of Effluent of Filter No. 50.*

[Parts per 100,000.]

| 1895.            | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | Bacteria per Cubic Centimeter. |
|------------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|
|                  |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |                                |
| May, . . .       | 4,580,000                                        | 61                      | 63        | .40    | .0004    | .0008       | .17       | .0230       | .0000     | .35              | 57                             | 141                            |
| June, . . .      | 4,740,000                                        | 71                      | 70        | .30    | .0006    | .0089       | .21       | .0260       | .0000     | .33              | 32                             | 64                             |
| July, . . .      | 4,760,000                                        | 72                      | 70        | .27    | .0005    | .0095       | .26       | .0330       | .0000     | .29              | 30                             | 82                             |
| August, . . .    | 4,860,000                                        | 73                      | 72        | .22    | .0023    | .0090       | .30       | .0330       | .0002     | .26              | 4                              | 34                             |
| September, . . . | 4,660,000                                        | 71                      | 71        | .18    | .0008    | .0088       | .29       | .0320       | .0000     | .18              | 14                             | 44                             |
| October, . . .   | 5,000,000                                        | 51                      | 53        | .48    | .0009    | .0126       | .23       | .0250       | .0000     | .53              | 23                             | 51                             |
| November, . . .  | 4,900,000                                        | 44                      | 44        | .59    | .0015    | .0151       | .20       | .0180       | .0000     | .58              | 102                            | 42                             |

*Filter No. 62.*

This continuous filter was started Sept. 2, 1895, and contained 48 inches in depth of sand of an effective size of 0.40 millimeter. The history of this filter during 1895 contains the following principal points:—

The sand for this filter was obtained from the beach at Plum Island on the sea coast 20 miles from Lawrence. Canal water was applied slowly from above until it covered the surface of the sand. The filter then stood full of water for forty-eight hours, and started, on September 2, to filter canal water continuously at a prescribed rate of 5,000,000 gallons per acre daily. A trap attached to the outlet prevented air from entering at this point. Owing to low water in the canal the gate on the outlet remained closed and the surface of the sand covered with water on September 22 and 28 for twenty-four and thirty-three hours, respectively. In order to remove clogging the surface of the sand was scraped as follows: on October 2, 0.30 inch of sand was removed; October 24, 0.50 inch; November 9, 0.47 inch; and on November 19, 0.41 inch. After scraping, the surface was not raked. On October 2 and 24 the filter was filled slowly from below with city water, but on November 9 and 19 canal water was applied above, immediately after scraping.

On September 19 the rate was fluctuated by closing the valve on the outlet for one minute and then opening the valve suddenly to the usual point. On October 19 the rate was fluctuated by throw-

ing the valve wide open for a minute and then closing it to the usual point.

A solution seeded with *B. prodigiosus* was mixed with the applied canal water in the ratio of 1 part to 170,000, for ten hours daily, from September 26 to November 23.

When the filter went out of operation on Nov. 23, 1895, the valve was thrown wide open and the sand allowed to drain.

A record of the daily (excepting Sundays and on some other occasions) bacterial analyses will be found in the following table:—

*Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 62, 1895.*

| DAY.          | SEPTEMBER.      |                 | OCTOBER.        |                 | NOVEMBER.       |                 |
|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. |
| 1, . . . . .  | -               | -               | 67              | 2               | 25              | 3               |
| 2, . . . . .  | -               | -               | -               | -               | -               | -               |
| 3, . . . . .  | -               | -               | 5,530           | 4               | -               | -               |
| 4, . . . . .  | -               | -               | -               | -               | 145             | 0               |
| 5, . . . . .  | -               | -               | 266             | 2               | -               | -               |
| 6, . . . . .  | 230             | -               | -               | -               | 45              | 0               |
| 7, . . . . .  | -               | -               | 160             | 1               | -               | -               |
| 8, . . . . .  | -               | -               | 223             | 0               | 57              | 0               |
| 9, . . . . .  | 120             | -               | -               | -               | -               | -               |
| 10, . . . . . | 69              | -               | -               | -               | -               | -               |
| 11, . . . . . | 65              | -               | -               | -               | 29              | 0               |
| 12, . . . . . | 94              | -               | 1,260           | 16              | -               | -               |
| 13, . . . . . | -               | -               | -               | -               | 21              | 0               |
| 14, . . . . . | -               | -               | 190             | 0               | -               | -               |
| 15, . . . . . | -               | -               | 144             | 4               | 28              | 0               |
| 16, . . . . . | 48              | -               | -               | -               | -               | -               |
| 17, . . . . . | 64              | -               | 132             | 0               | -               | -               |
| 18, . . . . . | 180             | -               | 97              | 7               | 30              | 0               |
| 19, . . . . . | 420             | -               | -               | -               | 67              | 0               |
| 20, . . . . . | 87              | -               | -               | -               | -               | -               |
| 21, . . . . . | 280             | -               | -               | -               | -               | -               |
| 22, . . . . . | -               | -               | 116             | 1               | -               | -               |
| 23, . . . . . | 1,078           | -               | 60              | 1               | 135             | 0               |
| 24, . . . . . | 81              | -               | 116             | 27              | -               | -               |
| 25, . . . . . | -               | -               | 196             | 3               | -               | -               |
| 26, . . . . . | 156             | 0               | -               | -               | -               | -               |
| 27, . . . . . | -               | -               | -               | -               | -               | -               |
| 28, . . . . . | 102             | 12              | 78              | 2               | -               | -               |
| 29, . . . . . | -               | -               | -               | -               | -               | -               |
| 30, . . . . . | -               | -               | 32              | 1               | -               | -               |
| 31, . . . . . | -               | -               | -               | -               | -               | -               |

*Monthly Averages of Analyses of Effluent of Filter No. 62.*

[Parts per 100,000.]

| 1895.        | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | Bacteria per Cubic Centimeter. |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |                                |
| September, . | 4,720,000                                        | 71                      | 71        | .20    | .0070    | .0131       | .29       | .0250       | .0001     | .23              | -                              | 135                            |
| October, .   | 4,900,000                                        | 51                      | 53        | .48    | .0015    | .0150       | .23       | .0250       | .0000     | .54              | 29                             | 142                            |
| November, .  | 4,720,000                                        | 44                      | 46        | .59    | .0021    | .0157       | .20       | .0210       | .0000     | .68              | 98                             | 56                             |

*Filter No. 63.*

This continuous filter was started Sept. 2, 1895, and contained 24 inches in depth of sand of an effective size of 0.16 millimeter. The history of its construction and operation during 1895 is as follows: —

After removing the sand from Filter No. 38, without disturbing the under-drains, 2 feet of Berkshire sand — a white, sharp, pure quartz sand, such as is used in the manufacture of glass — was put into the filter dry. Canal water was then applied from above until the surface of the sand was covered. Having stood full of water for forty-six hours the filter began, on September 2, to filter canal water continuously at a prescribed rate of 5,000,000 gallons per acre daily. A trap attached to the outlet prevented air from entering at that point. Owing to low water in the canal the gate on the outlet remained closed, and the surface of the sand covered with water on September 22 and 28, for periods varying from twenty-four to thirty-three hours. On September 21 the filter drained until the surface of the sand almost became uncovered. In order to remove clogging the surface of the sand was scraped as follows: on September 12, 0.39 inch of sand was removed; on September 19, 0.32 inch; October 2, 0.28 inch; October 9, 0.26 inch; October 16, 0.36 inch; October 19, 0.34 inch; October 28, 0.33 inch; November 2, 0.28 inch; November 7, 0.40 inch; November 16, 0.49 inch; November 19, 0.34 inch. After scraping, the filter was not raked, and canal water was applied above immediately, except on October 9, when the filter was filled slowly from below with city water. On November 9 the rate was fluctuated by opening the faucet for one minute, so that the normal rate was doubled.



A solution seeded with *B. prodigiosus* was mixed with the applied canal water in the proportion of 1 part to 170,000, for 10 hours a day (excepting Sundays and on some other occasions), from September 26 to November 23. On the latter date the filter went out of operation for the year. It was allowed to drain and the outlet remained open during the winter.

A record of the daily (excepting on Sundays and on certain other occasions) bacterial analyses will be found in the following table:—

*Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 63, 1895.*

| DAY.          | SEPTEMBER.      |                 | OCTOBER.        |                 | NOVEMBER.       |                 |
|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. |
| 1, . . . . .  | -               | -               | 85              | 6               | 46              | 0               |
| 2, . . . . .  | -               | -               | -               | -               | 60              | 0               |
| 3, . . . . .  | -               | -               | 10,028          | 8               | -               | -               |
| 4, . . . . .  | 910             | -               | -               | -               | 28              | 0               |
| 5, . . . . .  | 2,870           | -               | 238             | 0               | -               | -               |
| 6, . . . . .  | 625             | -               | -               | -               | 34              | 0               |
| 7, . . . . .  | -               | -               | 190             | 0               | -               | -               |
| 8, . . . . .  | -               | -               | 122             | 2               | 42              | 0               |
| 9, . . . . .  | 80              | -               | -               | -               | -               | -               |
| 10, . . . . . | 75              | -               | 98              | 0               | -               | -               |
| 11, . . . . . | 58              | -               | 3,570           | 0               | 35              | 0               |
| 12, . . . . . | 90              | -               | 415             | 0               | -               | -               |
| 13, . . . . . | -               | -               | -               | -               | 27              | 0               |
| 14, . . . . . | -               | -               | 420             | 2               | -               | -               |
| 15, . . . . . | -               | -               | 122             | 7               | 39              | 0               |
| 16, . . . . . | 42              | -               | -               | -               | -               | -               |
| 17, . . . . . | 23              | -               | 101             | 0               | -               | -               |
| 18, . . . . . | 280             | -               | 132             | 3               | 61              | 0               |
| 19, . . . . . | 2,742           | -               | -               | -               | 50              | 0               |
| 20, . . . . . | 441             | -               | -               | -               | -               | -               |
| 21, . . . . . | 3,427           | -               | -               | -               | -               | -               |
| 22, . . . . . | -               | -               | 65              | 0               | -               | -               |
| 23, . . . . . | 420             | -               | 37              | 0               | 65              | 0               |
| 24, . . . . . | 210             | -               | -               | -               | -               | -               |
| 25, . . . . . | -               | -               | 70              | 0               | -               | -               |
| 26, . . . . . | 160             | 1               | -               | -               | -               | -               |
| 27, . . . . . | -               | -               | -               | -               | -               | -               |
| 28, . . . . . | 78              | 0               | 42              | 3               | -               | -               |
| 29, . . . . . | -               | -               | -               | -               | -               | -               |
| 30, . . . . . | -               | -               | 30              | 0               | -               | -               |
| 31, . . . . . | -               | -               | -               | -               | -               | -               |

*Monthly Averages of Analyses of Effluent of Filter No. 63.*

[Parts per 100,000.]

| 1895.        | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | Bacteria per Cubic Centimeter. |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |                                |
| September, . | 4,500,000                                        | 71                      | 71        | .24    | .0039    | .0123       | .29       | .0260       | .0003     | .25              | -                              | 237                            |
| October, . . | 4,740,000                                        | 51                      | 49        | .49    | .0019    | .0146       | .23       | .0260       | .0002     | .57              | 27                             | 78                             |
| November, .  | 4,720,000                                        | 44                      | 47        | .59    | .0019    | .0147       | .20       | .0240       | .0000     | .59              | 98                             | 37                             |

*Filter No. 64.*

This continuous filter was started Sept. 2, 1895, and contained 12 inches in depth of sand of an effective size of 0.16 millimeter. The method of construction and the history of this filter during 1895 is as follows:—

After removing the sand from Filter No. 46, without disturbing the under-drains, 1 foot of Berkshire sand—similar to that already described under Filter No. 63—was put into the filter dry. Canal water was then applied from above until the surface of the sand was covered. Having stood full of water for forty-six hours, the filter began to filter canal water continuously, on September 2, at a prescribed rate of 5,000,000 gallons per acre daily. A trap attached to the outlet prevented air from entering at that point. Owing to low water in the canal the filter remained closed and the surface of the sand covered with water, on the following dates: September 22 for twenty-four hours and September 28 for thirty-three hours. In order to remove clogging the surface of the sand was scraped as follows: on September 10, 0.26 inch of sand was removed; September 16, 0.30 inch; September 21, 0.28 inch; September 28, 0.35 inch; October 5, 0.27 inch; October 11, 0.26 inch; October 26, 0.32 inch; October 17, 0.42 inch; October 21, 0.28 inch; October 26, 0.26 inch; November 1, 0.34 inch; November 5, 0.31 inch; November 9, 0.35 inch; November 15, 0.34 inch; and November 19, 0.34 inch. After scraping, the surface was not raked but canal water applied from above immediately.

On October 29 the rate was fluctuated by increasing it for one minute from 5,000,000 to 7,500,000 gallons per acre daily. On November 23 the filter was shut off for the winter, and the gate on the outlet left open to allow the filter to drain.

A solution seeded with *Bacillus prodigiosus* was mixed with the applied canal water in the ratio of 1 part to 170,000 parts, for ten hours a day (excepting Sundays and on some other occasions), from September 26 to November 23.

A record of the daily bacterial analyses (excepting on Sundays and on certain other days) will be found in the following table:—

*Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 64, 1895.*

| DAY.          | SEPTEMBER.      |                 | OCTOBER.        |                 | NOVEMBER.       |                 |
|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. | Water Bacteria. | B. Prodigiosus. |
| 1, . . . . .  | -               | -               | 110             | 18              | -               | -               |
| 2, . . . . .  | -               | -               | -               | -               | -               | -               |
| 3, . . . . .  | -               | -               | 6,969           | 3               | -               | -               |
| 4, . . . . .  | 1,190           | -               | -               | -               | 34              | 0               |
| 5, . . . . .  | 4,634           | -               | 347             | 4               | -               | -               |
| 6, . . . . .  | 266             | -               | -               | -               | 31              | 0               |
| 7, . . . . .  | -               | -               | 130             | 2               | -               | -               |
| 8, . . . . .  | -               | -               | 118             | 0               | 47              | 0               |
| 9, . . . . .  | 70              | -               | -               | -               | -               | -               |
| 10, . . . . . | 40              | -               | 2,760           | 12              | -               | -               |
| 11, . . . . . | 71              | -               | -               | -               | 44              | 4               |
| 12, . . . . . | 97              | -               | 714             | 4               | -               | -               |
| 13, . . . . . | -               | -               | -               | -               | 25              | 0               |
| 14, . . . . . | -               | -               | 182             | 0               | -               | -               |
| 15, . . . . . | -               | -               | 135             | 4               | 152             | 2               |
| 16, . . . . . | 60              | -               | -               | -               | -               | -               |
| 17, . . . . . | 22              | -               | 280             | 0               | -               | -               |
| 18, . . . . . | 791             | -               | 170             | 2               | 106             | -               |
| 19, . . . . . | 450             | -               | -               | -               | 65              | 11              |
| 20, . . . . . | 195             | -               | -               | -               | -               | -               |
| 21, . . . . . | 540             | -               | -               | -               | -               | -               |
| 22, . . . . . | -               | -               | 41              | 0               | -               | -               |
| 23, . . . . . | 420             | -               | 30              | 0               | 122             | 4               |
| 24, . . . . . | 116             | -               | -               | -               | -               | -               |
| 25, . . . . . | -               | -               | 44              | 5               | -               | -               |
| 26, . . . . . | 190             | 4               | -               | -               | -               | -               |
| 27, . . . . . | -               | -               | -               | -               | -               | -               |
| 28, . . . . . | 110             | 8               | 41              | 0               | -               | -               |
| 29, . . . . . | -               | -               | -               | -               | -               | -               |
| 30, . . . . . | -               | -               | 28              | 0               | -               | -               |
| 31, . . . . . | -               | -               | -               | -               | -               | -               |

*Monthly Averages of Analyses of Effluent of Filter No. 64.*

[Parts per 100,000.]

| 1895.        | Quantity of Effluent.<br>Gallons per Acre Daily. | TEMPERATURE.<br>DEG. F. |           | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | Bacteria per Cubic Centimeter. |
|--------------|--------------------------------------------------|-------------------------|-----------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|--------------------------------|
|              |                                                  | Applied Water.          | Effluent. |        | Free.    | Alb.-mhold. |           | Nitrates.   | Nitrites. |                  |                                |                                |
| September, . | 4,480,000                                        | 71                      | 71        | .25    | .0032    | .0123       | .29       | .0250       | .0003     | .26              | -                              | 123                            |
| October, . . | 4,680,000                                        | 51                      | 53        | .51    | .0009    | .0146       | .23       | .0240       | .0000     | .57              | 82                             | 74                             |
| November, .  | 4,520,000                                        | 44                      | 46        | .59    | .0030    | .0155       | .20       | .0230       | .0000     | .60              | 103                            | 45                             |

## LAWRENCE CITY FILTER.

The filter of the water supply system of the city of Lawrence is 2.5 acres in area, was first put in operation Sept. 20, 1893, and its construction and action was described in the report of the State Board of Health for that year. From the date of starting this filter up to the present time it has been in continuous use, and not once has the unfiltered river water entered the reservoir or the service pipes of the city water supply.

The average bacterial efficiency of the filter for the entire year has always been about 99 per cent., but varies with different seasons, being considerably greater in summer than in winter. The most important reason for the lower bacterial efficiency in winter is that, contrary to the advice of the designer, the filter remains uncovered and unprotected from the severe cold of the winters of the climate of Lawrence. In consequence of this a thick coating of ice forms upon the filter, and, to enable the surface of the filter to be cleaned of clogged and dirty sand, and thus kept in operation, this layer of ice, sometimes approximating 2 feet in thickness, has to be removed. Its removal is slowly accomplished by the city laborers and the surface of the filter very much disturbed during the process. With the force employed the removal of the main body of the ice is so slowly accomplished that in order to get a sufficient daily volume of water through the filter, it is necessary to frequently stop removing the thick ice and remove the newly formed ice and scrape the beds just previously scraped. With these conditions abnormal and unnecessary results are obtained. That is to say, as a result of this management, a small portion of the filter is, for weeks at a time, filtering a very large proportion of the water pumped. The surface of the filter is divided by drains and elevations of its surface into thirty-three sections or beds, and between December 11 and April 10 the first two beds (beginning at the end of the filter nearest the pumping house) were scraped and raked eight times, the next eighteen beds five and one-half times and the remaining thirteen beds two and one-half times, and these last were not scraped at all during January and February.

This method of operation is unfavorable to obtaining efficient filtration, and if the filter remains uncovered it will be necessary to remove the ice with sufficient rapidity to clean all of the beds monthly and to avoid repeated scraping of the same beds and the

consequent filtration of a large part of the water through a small area of the filter at a very high rate.

An experiment to illustrate the effect of this treatment upon bacterial efficiency was made with Filter No. 3 B at the station. About one-quarter of the surface of this filter was scraped and then disturbed to the depth of several inches and the filter started at its rate of filtration of 5,000,000 gallons per acre daily. The average number of bacteria per cubic centimeter in the effluent of this filter before this treatment was 7 per cubic centimeter; following the treatment the number quickly increased to a maximum of 1,897 per cubic centimeter and not for several days did the bacterial efficiency of the filter return to the normal. This is parallel to the treatment of the Lawrence city filter in the winter months, which results in giving at times the high numbers of bacteria in its effluent presented in the tables on page 573, and those in charge have been repeatedly advised against this unfavorable method of operation.

Beginning Nov. 15, 1895, a daily bacterial analysis was made of the river water before and after its passage through the filter, and as it flowed from taps at the city hall and experiment station. This daily bacterial examination was continued until May, and the results are presented beyond. The hygienic efficiency of the filter is shown by a table on page 7.

During the winter months the filter is at times operated continuously.

#### *Cost of Operation of the Filter.*

During 1895, 1,096,000,000 gallons of water passed through the city filter, and upon page 7 of the report of the Lawrence water board for the year 1895 it is stated that the cost of maintenance of the filter for the year was \$11,038. Exclusive of amounts not properly chargeable to filter maintenance, such as grading, paving, care of lawns and improvements about the pumping station and filter beds, the total expense for maintenance was \$7,400, or \$6.75 per million gallons of water filtered. The itemized figures for the year kindly furnished by Mr. Salisbury, the superintendent of the Lawrence water department, are as follows: for scraping the filter and replacing sand, \$3,477; for removing ice, \$2,903; for washing 1,500 cubic yards of sand, \$1,020. For scraping and replacing sand only, the cost was \$3.10 per million gallons filtered. All laborers upon this work are paid \$2 per day.

*Monthly Averages of Analyses of the Merrimack River Water as it flows upon the Lawrence City Filter.*

[Parts per 100,000.]

| 1895.            | Tempera-<br>ture.<br>—<br>Deg. F. | Color. | AMMONIA. |             |         | Chlorine. | NITROGEN AS |           | Oxygen<br>Consumed. | Hardness. | Bacteria per Cubic<br>Centimeter. |
|------------------|-----------------------------------|--------|----------|-------------|---------|-----------|-------------|-----------|---------------------|-----------|-----------------------------------|
|                  |                                   |        | Free.    | ALBUMINOID. |         |           | Nitrates.   | Nitrites. |                     |           |                                   |
|                  |                                   |        |          | Total.      | Soluble |           |             |           |                     |           |                                   |
| January, . . .   | 32                                | .36    | .0119    | .0203       | .0168   | .29       | .0200       | .0002     | .41                 | 1.9       | 20,000                            |
| February, . . .  | 32                                | .38    | .0132    | .0217       | .0173   | .31       | .0190       | .0002     | .43                 | 2.0       | 15,000                            |
| March, . . .     | 32                                | .43    | .0079    | .0202       | .0159   | .23       | .0220       | .0001     | .48                 | 1.4       | 17,000                            |
| April, . . .     | 45                                | .44    | .0027    | .0157       | .0134   | .17       | .0140       | .0000     | .48                 | 1.3       | 9,000                             |
| May, . . .       | 62                                | .46    | .0061    | .0178       | .0153   | .16       | .0110       | .0001     | .46                 | 1.0       | 7,000                             |
| June, . . .      | 72                                | .48    | .0099    | .0223       | .0164   | .20       | .0090       | .0001     | .32                 | 1.6       | 9,000                             |
| July, . . .      | 75                                | .43    | .0134    | .0243       | .0178   | .27       | .0110       | .0003     | .38                 | 1.8       | 10,000                            |
| August, . . .    | 73                                | .39    | .0168    | .0225       | .0177   | .30       | .0100       | .0004     | .36                 | 1.9       | 5,000                             |
| September, . . . | 68                                | .35    | .0157    | .0198       | .0163   | .29       | .0080       | .0004     | .30                 | 2.0       | 5,000                             |
| October, . . .   | 53                                | .55    | .0098    | .0235       | .0213   | .24       | .0120       | .0003     | .52                 | 1.9       | 19,000                            |
| November, . . .  | 45                                | .65    | .0041    | .0196       | .0174   | .20       | .0140       | .0000     | .61                 | 1.6       | 7,000                             |
| December, . . .  | 35                                | .54    | .0047    | .0147       | .0134   | .18       | .0150       | .0001     | .48                 | 1.5       | 5,000                             |

*Monthly Averages of Effluent from the City Filter.*

[Parts per 100,000.]

| 1895.            | Tempera-<br>ture.<br>—<br>Deg F. | Color. | AMMONIA. |             |          | Chlorine. | NITROGEN AS |           | Oxygen<br>Consumed. | Hardness. | Bacteria per Cubic<br>Centimeter |
|------------------|----------------------------------|--------|----------|-------------|----------|-----------|-------------|-----------|---------------------|-----------|----------------------------------|
|                  |                                  |        | Free.    | ALBUMINOID. |          |           | Nitrates.   | Nitrites. |                     |           |                                  |
|                  |                                  |        |          | Total.      | Soluble. |           |             |           |                     |           |                                  |
| January, . . .   | 35                               | .31    | .0123    | .0089       | .0074    | .31       | .0300       | .0001     | .28                 | 2.5       | 368                              |
| February, . . .  | 34                               | .36    | .0117    | .0115       | .0096    | .32       | .0350       | .0001     | .31                 | 2.5       | 357                              |
| March, . . .     | 35                               | .34    | .0102    | .0104       | .0097    | .29       | .0350       | .0000     | .36                 | 2.0       | 200                              |
| April, . . .     | 43                               | .42    | .0130    | .0092       | .0079    | .19       | .0360       | .0001     | .34                 | 2.3       | 67                               |
| May, . . .       | 62                               | .37    | .0067    | .0093       | .0082    | .17       | .0390       | .0000     | .32                 | 1.7       | 68                               |
| June, . . .      | 72                               | .37    | .0062    | .0090       | .0083    | .24       | .0410       | .0001     | .30                 | 2.2       | 68                               |
| July, . . .      | 73                               | .33    | .0075    | .0097       | .0083    | .39       | .0450       | .0001     | .23                 | 2.4       | 56                               |
| August, . . .    | 74                               | .36    | .0080    | .0082       | .0073    | .33       | .0370       | .0001     | .22                 | 2.7       | 38                               |
| September, . . . | 69                               | .29    | .0048    | .0087       | .0066    | .31       | .0360       | .0002     | .21                 | 2.4       | 40                               |
| October, . . .   | 55                               | .42    | .0079    | .0099       | .0093    | .38       | .0360       | .0003     | .32                 | 2.3       | 60                               |
| November, . . .  | 45                               | .60    | .0137    | .0128       | .0113    | .24       | .0350       | .0000     | .42                 | 2.8       | 52                               |
| December, . . .  | 38                               | .54    | .0118    | .0088       | .0086    | .21       | .0450       | .0001     | .34                 | 2.6       | 93                               |

*Monthly Averages of Analyses of Water from the Outlet of the Distributing Reservoir.*

[Parts per 100,000.]

| 1895.            | Tempera-<br>ture.<br>—<br>Deg. F. | Color. | AMMONIA. |             |          | Chlorine. | NITROGEN AS |           | Oxygen<br>Consumed. | Hardness. | Bacteria per Cubic<br>Centimeter. |
|------------------|-----------------------------------|--------|----------|-------------|----------|-----------|-------------|-----------|---------------------|-----------|-----------------------------------|
|                  |                                   |        | Free.    | ALBUMINOID. |          |           | Nitrates.   | Nitrites. |                     |           |                                   |
|                  |                                   |        |          | Total.      | Soluble. |           |             |           |                     |           |                                   |
| January, . . .   | 35                                | .31    | .0092    | .0094       | .0082    | .31       | .0340       | .0000     | .28                 | 2.5       | 121                               |
| February, . . .  | 34                                | .33    | .0100    | .0090       | .0085    | .32       | .0410       | .0000     | .29                 | 2.5       | 143                               |
| March, . . .     | 36                                | .35    | .0116    | .0106       | .0093    | .33       | .0470       | .0000     | .30                 | 2.5       | 232                               |
| April, . . .     | 40                                | .37    | .0075    | .0110       | .0085    | .22       | .0470       | .0000     | .33                 | 2.2       | 105                               |
| May, . . .       | 59                                | .33    | .0022    | .0099       | .0066    | .19       | .0450       | .0000     | .29                 | 1.7       | 367                               |
| June, . . .      | 66                                | .31    | .0083    | .0089       | .0079    | .24       | .0410       | .0001     | .27                 | 2.2       | 112                               |
| July, . . .      | 71                                | .27    | .0023    | .0099       | .0081    | .28       | .0450       | .0001     | .21                 | 2.4       | 69                                |
| August, . . .    | 73                                | .25    | .0020    | .0085       | .0073    | .32       | .0380       | .0003     | .20                 | 2.4       | 51                                |
| September, . . . | 68                                | .20    | .0025    | .0076       | .0065    | .31       | .0390       | .0003     | .18                 | 2.4       | 75                                |
| October, . . .   | 56                                | .24    | .0020    | .0077       | .0072    | .29       | .0420       | .0001     | .17                 | 2.4       | 36                                |
| November, . . .  | 46                                | .54    | .0060    | .0134       | .0117    | .25       | .0350       | .0000     | .39                 | 2.3       | 36                                |
| December, . . .  | 38                                | .53    | .0062    | .0101       | .0097    | .21       | .0330       | .0000     | .37                 | 2.2       | 62                                |

*Monthly Averages of Analyses of Water from a Tap at the Lawrence City Hall.*

[Parts per 100,000.]

| 1895.            | Tempera-<br>ture.<br>—<br>Deg. F. | Color. | AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen<br>Consumed. | Hardness. | Bacteria per<br>Cubic Centi-<br>meter. |
|------------------|-----------------------------------|--------|----------|------------------|-----------|-------------|-----------|---------------------|-----------|----------------------------------------|
|                  |                                   |        | Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                     |           |                                        |
| January, . . .   | 37                                | .31    | .0071    | .0085            | .31       | .0340       | .0001     | .28                 | 2.4       | 149                                    |
| February, . . .  | 36                                | .33    | .0082    | .0088            | .32       | .0410       | .0001     | .28                 | 2.4       | 104                                    |
| March, . . .     | 39                                | .32    | .0096    | .0086            | .35       | .0480       | .0000     | .29                 | 2.6       | 104                                    |
| April, . . .     | 41                                | .36    | .0064    | .0094            | .22       | .0460       | .0000     | .31                 | 2.3       | 92                                     |
| May, . . .       | 57                                | .32    | .0010    | .0089            | .20       | .0470       | .0000     | .26                 | 1.7       | 171                                    |
| June, . . .      | 64                                | .29    | .0009    | .0081            | .24       | .0420       | .0000     | .26                 | 2.2       | 64                                     |
| July, . . .      | 69                                | .24    | .0015    | .0081            | .29       | .0430       | .0000     | .19                 | 2.3       | 56                                     |
| August, . . .    | 70                                | .25    | .0011    | .0078            | .31       | .0390       | .0000     | .18                 | 2.4       | 55                                     |
| September, . . . | 65                                | .21    | .0012    | .0071            | .31       | .0390       | .0000     | .17                 | 2.4       | 50                                     |
| October, . . .   | 57                                | .22    | .0015    | .0075            | .29       | .0400       | .0000     | .16                 | 2.4       | 81                                     |
| November, . . .  | 47                                | .52    | .0043    | .0118            | .25       | .0350       | .0000     | .38                 | 2.5       | 50                                     |
| December, . . .  | 41                                | .51    | .0050    | .0091            | .21       | .0360       | .0001     | .37                 | 2.1       | 62                                     |

*Monthly Averages of Analyses of Water from a Tap at the Lawrence Experiment Station.*

[Parts per 100,000.]

| 1895.            | Temperature.<br>Deg. F. | Color. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Per Cent. of Dissolved Oxygen. | Hardness. | Bacteria per Cubic Centimeter. |
|------------------|-------------------------|--------|----------|-------------|-----------|-------------|-----------|------------------|--------------------------------|-----------|--------------------------------|
|                  |                         |        | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |                                |           |                                |
| January, . . .   | 39                      | .32    | .0048    | .0081       | .31       | .0350       | .0003     | .26              | 100                            | 2.5       | 125                            |
| February, . . .  | 38                      | .33    | .0059    | .0079       | .32       | .0430       | .0000     | .27              | 89                             | 2.6       | 107                            |
| March, . . .     | 40                      | .32    | .0085    | .0089       | .35       | .0470       | .0000     | .28              | 81                             | 2.6       | 110                            |
| April, . . .     | 41                      | .35    | .0045    | .0092       | .22       | .0430       | .0000     | .31              | 81                             | 2.2       | 85                             |
| May, . . .       | 53                      | .30    | .0008    | .0085       | .20       | .0450       | .0000     | .26              | 67                             | 1.7       | 108                            |
| June, . . .      | 60                      | .27    | .0003    | .0072       | .27       | .0460       | .0000     | .24              | 55                             | 2.2       | 75                             |
| July, . . .      | 66                      | .21    | .0003    | .0078       | .29       | .0420       | .0000     | .18              | 58                             | 2.2       | 85                             |
| August, . . .    | 70                      | .17    | .0003    | .0066       | .32       | .0390       | .0000     | .17              | 51                             | 2.4       | 48                             |
| September, . . . | 67                      | .17    | .0002    | .0052       | .31       | .0380       | .0000     | .15              | 51                             | 2.4       | 53                             |
| October, . . .   | 58                      | .19    | .0001    | .0053       | .27       | .0410       | .0000     | .15              | 78                             | 2.3       | 40                             |
| November, . . .  | 48                      | .50    | .0013    | .0116       | .25       | .0350       | .0000     | .38              | 100                            | 2.2       | 47                             |
| December, . . .  | 45                      | .49    | .0021    | .0093       | .21       | .0360       | .0000     | .38              | 95                             | 2.2       | 47                             |

*Daily Bacterial Results, Lawrence City Water.*

[Bacteria per Cubic Centimeter.]

| DATE — 1895.       | In River Water. | IN FILTERED WATER FROM |                   |                   |                            | Condition of Surface when Pumps were Stopped. | Loss of Head. Feet. |
|--------------------|-----------------|------------------------|-------------------|-------------------|----------------------------|-----------------------------------------------|---------------------|
|                    |                 | City Filter.           | Reservoir Outlet. | Tap at City Hall. | Tap at Experiment Station. |                                               |                     |
| November 11, . . . | 5,800           | 40                     | 19                | 41                | 32                         | Drained.                                      | 7.3                 |
| 12, . . .          | 6,400           | 55                     | 37                | 19                | 27                         | Drained.                                      | 7.3                 |
| 13, . . .          | 4,100           | 62                     | 40                | 37                | 40                         | Drained.                                      | 5.6                 |
| 14, . . .          | 6,200           | 42                     | 26                | 31                | 26                         | Drained.                                      | 5.3                 |
| 15, . . .          | 11,500          | 57                     | 49                | 36                | 38                         | Covered.                                      | 5.8                 |
| 16, . . .          | 11,200          | 65                     | 51                | 49                | 52                         | Covered.                                      | 6.5                 |
| 17, . . .          | -               | -                      | -                 | -                 | -                          | -                                             | -                   |
| 18, . . .          | 11,000          | 74                     | 52                | 61                | 64                         | Covered.                                      | 4.6                 |
| 19, . . .          | 10,500          | 76                     | 108               | 62                | 60                         | Covered.                                      | 5.6                 |
| 20, . . .          | 8,700           | 75                     | 45                | 42                | 60                         | Covered.                                      | 6.4                 |
| 21, . . .          | 14,000          | 84                     | 40                | 58                | 51                         | Drained.                                      | 6.1                 |
| 22, . . .          | 10,900          | 120                    | 58                | 60                | 69                         | Covered.                                      | 5.1                 |
| 23, . . .          | 13,000          | 120                    | 95                | 74                | 81                         | Covered.                                      | 5.1                 |
| 24, . . .          | -               | -                      | -                 | -                 | -                          | -                                             | -                   |
| 25, . . .          | 6,200           | 70                     | 58                | 51                | 49                         | Covered.                                      | 5.2                 |
| 26, . . .          | 5,800           | 50                     | 65                | 57                | 57                         | Drained.                                      | 5.3                 |
| 27, . . .          | 5,800           | 49                     | 70                | 63                | 75                         | Drained.                                      | 5.7                 |
| 28, . . .          | -               | -                      | -                 | -                 | -                          | Drained.                                      | 5.1                 |
| 29, . . .          | 5,800           | 18                     | 49                | 42                | 36                         | Drained.                                      | 5.4                 |
| 30, . . .          | 10,500          | 78                     | 89                | 74                | 65                         | Drained.                                      | 5.6                 |



*Daily Bacterial Results, Lawrence City Water — Continued.*

[Bacteria per Cubic Centimeter.]

| DATE—1895.          | In River Water. | IN FILTERED WATER FROM |                   |                   |                            | Condition of Surface when Pumps were Stopped. | Loss of Head.—Feet. |
|---------------------|-----------------|------------------------|-------------------|-------------------|----------------------------|-----------------------------------------------|---------------------|
|                     |                 | City Filter.           | Reservoir Outlet. | Tap at City Hall. | Tap at Experiment Station. |                                               |                     |
| December 1, . . . . | —               | —                      | —                 | —                 | —                          | Drained.                                      | —                   |
| 2, . . . .          | 5,500           | 61                     | 67                | 68                | 88                         | Covered.                                      | 4.8                 |
| 3, . . . .          | 4,000           | 35                     | 51                | 66                | 41                         | Drained.                                      | 5.1                 |
| 4, . . . .          | 4,300           | 67                     | 50                | 44                | 62                         | Covered.                                      | 4.9                 |
| 5, . . . .          | 4,900           | 49                     | 65                | 55                | 42                         | Covered.                                      | 4.9                 |
| 6, . . . .          | 11,000          | 38                     | 43                | 53                | 55                         | Drained.                                      | 5.3                 |
| 7, . . . .          | 4,500           | 87                     | 63                | 69                | 43                         | Covered.                                      | 5.6                 |
| 8, . . . .          | —               | —                      | —                 | —                 | —                          | —                                             | —                   |
| 9, . . . .          | 3,100           | 51                     | 50                | 47                | 37                         | Covered.                                      | 4.8                 |
| 10, . . . .         | 3,400           | 50                     | 41                | 38                | 47                         | Covered.                                      | 5.1                 |
| 11, . . . .         | 4,300           | 55                     | 64                | 60                | 46                         | Drained.                                      | 5.5                 |
| 12, . . . .         | 3,400           | 64                     | 35                | 39                | 36                         | Covered.                                      | 5.4                 |
| 13, . . . .         | 3,500           | 112                    | 71                | 37                | 49                         | Covered.                                      | 5.3                 |
| 14, . . . .         | 6,100           | 210                    | 64                | 51                | 51                         | Covered.                                      | —                   |
| 15, . . . .         | 7,200           | 180                    | 79                | 61                | 47                         | —                                             | 4.6                 |
| 16, . . . .         | 4,500           | 118                    | 56                | 41                | 56                         | Covered.                                      | 4.6                 |
| 17, . . . .         | —               | —                      | —                 | —                 | —                          | Covered.                                      | 4.4                 |
| 18, . . . .         | 6,700           | 92                     | 62                | 53                | 47                         | Covered.                                      | 5.3                 |
| 19, . . . .         | 11,200          | 130                    | 40                | 50                | 58                         | Drained.                                      | 5.8                 |
| 20, . . . .         | 6,100           | 41                     | 51                | 42                | 34                         | Drained.                                      | 5.5                 |
| 21, . . . .         | 5,900           | 66                     | 49                | 48                | 48                         | Covered.                                      | 5.6                 |
| 22, . . . .         | —               | —                      | —                 | —                 | —                          | —                                             | —                   |
| 23, . . . .         | 7,800           | 105                    | 67                | 74                | —                          | Covered.                                      | 5.2                 |
| 24, . . . .         | 16,000          | 124                    | 84                | 70                | 67                         | Covered.                                      | 5.5                 |
| 25, . . . .         | —               | —                      | —                 | —                 | —                          | —                                             | —                   |
| 26, . . . .         | 7,500           | 109                    | 85                | 80                | 104                        | Covered.                                      | 5.3                 |
| 27, . . . .         | 11,200          | 52                     | 145               | 68                | 52                         | Drained.                                      | 6.5                 |
| 28, . . . .         | 11,500          | 76                     | 82                | 72                | 95                         | Drained.                                      | 6.5                 |
| 29, . . . .         | —               | —                      | —                 | —                 | —                          | Covered.                                      | 5.9                 |
| 30, . . . .         | —               | —                      | —                 | 77                | 76                         | Drained.                                      | 5.5                 |
| 31, . . . .         | 8,300           | 55                     | 78                | 80                | 68                         | Drained.                                      | 6.1                 |

*Daily Bacterial Results, Lawrence City Water — Continued.*

[Bacteria per Cubic Centimeter.]

| DATE — 1896.     | In River Water. | IN FILTERED WATER FROM |                   |                   |                            | Condition of Surface when Pumps were Stopped. | Loss of Head. Feet. |
|------------------|-----------------|------------------------|-------------------|-------------------|----------------------------|-----------------------------------------------|---------------------|
|                  |                 | City Filter.           | Reservoir Outlet. | Tap at City Hall. | Tap at Experiment Station. |                                               |                     |
| January 1, . . . | 7,000           | 85                     | 101               | 82                | 80                         | Drained.                                      | 5.8                 |
| 2, . . .         | 5,000           | 67                     | 76                | 57                | 53                         | Drained.                                      | 5.3                 |
| 3, . . .         | 6,700           | 74                     | 132               | 68                | 59                         | Drained.                                      | 6.3                 |
| 4, . . .         | 5,400           | 93                     | 64                | 46                | —                          | Drained.                                      | 6.5                 |
| 5, . . .         | —               | —                      | —                 | —                 | —                          | Drained.                                      | —                   |
| 6, . . .         | 4,800           | 47                     | 112               | 62                | 49                         | Covered.                                      | 5.4                 |
| 7, . . .         | 5,500           | 79                     | 120               | 74                | 68                         | Covered.                                      | 5.7                 |
| 8, . . .         | 4,100           | 126                    | 92                | 85                | 70                         | Covered.                                      | 5.7                 |
| 9, . . .         | 18,200          | 233                    | 112               | 78                | 63                         | Covered.                                      | 5.3                 |
| 10, . . .        | 5,500           | 433                    | 93                | 75                | 72                         | Covered.                                      | 5.0                 |
| 11, . . .        | 7,000           | 567                    | 205               | 125               | 88                         | Covered.                                      | 4.7                 |
| 12, . . .        | —               | —                      | —                 | —                 | —                          | Covered.                                      | —                   |
| 13, . . .        | 10,200          | 588                    | 170               | 113               | 72                         | Covered.                                      | 4.3                 |
| 14, . . .        | 5,000           | 313                    | 135               | 120               | 84                         | Covered.                                      | 4.5                 |
| 15, . . .        | 15,000          | 410                    | 175               | 118               | 107                        | Covered.                                      | 4.6                 |
| 16, . . .        | 10,200          | 389                    | 240               | 170               | 116                        | Covered.                                      | 4.5                 |
| 17, . . .        | 10,900          | 231                    | 223               | 151               | 106                        | Covered.                                      | 4.5                 |
| 18, . . .        | 13,000          | 198                    | 231               | 115               | 111                        | Covered.                                      | 4.9                 |
| 19, . . .        | —               | —                      | —                 | —                 | —                          | Covered.                                      | —                   |
| 20, . . .        | 12,000          | 130                    | 170               | 125               | 101                        | Covered.                                      | 4.9                 |
| 21, . . .        | 8,200           | 57                     | 162               | 144               | 105                        | Covered.                                      | 6.2                 |
| 22, . . .        | 6,500           | 62                     | 162               | 93                | 89                         | Drained.                                      | 7.4                 |
| 23, . . .        | 3,500           | 52                     | 61                | 52                | 36                         | Covered.                                      | 6.5                 |
| 24, . . .        | 7,200           | 52                     | 116               | 57                | 60                         | Covered.                                      | 6.1                 |
| 25, . . .        | 4,500           | 52                     | 65                | 62                | 65                         | Covered.                                      | 6.6                 |
| 26, . . .        | —               | —                      | —                 | —                 | —                          | Covered.                                      | —                   |
| 27, . . .        | 8,100           | 71                     | 117               | 74                | 69                         | Covered.                                      | 6.3                 |
| 28, . . .        | 4,800           | 25                     | 49                | 40                | 34                         | Covered.                                      | 7.6                 |
| 29, . . .        | 4,100           | 59                     | 65                | 78                | 69                         | Covered.                                      | 7.9                 |
| 30, . . .        | 4,100           | 53                     | 62                | 62                | 49                         | Covered.                                      | 8.5                 |
| 31, . . .        | 7,200           | 36                     | 64                | 61                | 61                         | Drained.                                      | 7.5                 |

*Daily Bacterial Results, Lawrence City Water — Continued.*

[Bacteria per Cubic Centimeter.]

| DATE — 1896.      | In River Water. | IN FILTERED WATER FROM |                   |                   |                            | Condition of Surface when Pumps were Stopped. | Loss of Head. — Feet. |
|-------------------|-----------------|------------------------|-------------------|-------------------|----------------------------|-----------------------------------------------|-----------------------|
|                   |                 | City Filter.           | Reservoir Outlet. | Tap at City Hall. | Tap at Experiment Station. |                                               |                       |
| February 1, . . . | 6,700           | 93                     | 64                | 55                | 48                         | Covered.                                      | 5.3                   |
| 2, . . .          | —               | —                      | —                 | —                 | —                          | —                                             | —                     |
| 3, . . .          | 3,400           | 75                     | 47                | 27                | 31                         | Covered.                                      | 5.0                   |
| 4, . . .          | 4,200           | 136                    | 70                | 61                | —                          | Covered.                                      | 5.6                   |
| 5, . . .          | 6,000           | 63                     | —                 | 58                | 49                         | Drained.                                      | 6.4                   |
| 6, . . .          | 9,500           | 322                    | —                 | —                 | 69                         | Covered.                                      | 5.8                   |
| 7, . . .          | 21,400          | 580                    | 169               | 61                | 74                         | Covered.                                      | 5.9                   |
| 8, . . .          | 35,000          | 567                    | 263               | 216               | 95                         | Drained.                                      | 6.5                   |
| 9, . . .          | —               | —                      | —                 | —                 | —                          | —                                             | —                     |
| 10, . . .         | 21,000          | 385                    | 356               | 212               | 202                        | Covered.                                      | 5.6                   |
| 11, . . .         | 14,000          | 567                    | 243               | 210               | 196                        | Covered.                                      | 7.0                   |
| 12, . . .         | 13,900          | 108                    | 180               | 247               | 162                        | Drained.                                      | 7.2                   |
| 13, . . .         | 14,000          | 330                    | 250               | 250               | 203                        | Drained.                                      | 7.2                   |
| 14, . . .         | 11,000          | 191                    | 254               | 184               | 139                        | Drained.                                      | 7.4                   |
| 15, . . .         | 7,700           | 316                    | 128               | 175               | 120                        | Covered.                                      | 6.5                   |
| 16, . . .         | —               | —                      | —                 | —                 | —                          | —                                             | —                     |
| 17, . . .         | 11,000          | 425                    | 261               | 223               | 200                        | Covered.                                      | 5.1                   |
| 18, . . .         | 9,900           | 356                    | 250               | 232               | 204                        | Covered.                                      | 5.0                   |
| 19, . . .         | 12,000          | 521                    | 310               | 209               | 192                        | Covered.                                      | 5.0                   |
| 20, . . .         | 14,000          | 346                    | 370               | 220               | 160                        | Covered.                                      | 4.9                   |
| 21, . . .         | 12,000          | 327                    | 223               | 143               | 118                        | Covered.                                      | 5.0                   |
| 22, . . .         | 15,000          | 162                    | 111               | 235               | 168                        | Drained.                                      | 5.7                   |
| 23, . . .         | —               | —                      | —                 | —                 | —                          | —                                             | —                     |
| 24, . . .         | 10,000          | 198                    | 205               | 185               | 182                        | Covered.                                      | 5.0                   |
| 25, . . .         | 15,000          | 360                    | 174               | 132               | 157                        | Covered.                                      | 5.1                   |
| 26, . . .         | 12,000          | 554                    | 770               | 150               | 175                        | Drained.                                      | 5.6                   |
| 27, . . .         | —               | —                      | —                 | —                 | —                          | Covered.                                      | 5.7                   |
| 28, . . .         | —               | —                      | —                 | —                 | —                          | Drained.                                      | 5.9                   |
| 29, . . .         | —               | —                      | —                 | —                 | —                          | Covered.                                      | 5.7                   |

*Daily Bacterial Results, Lawrence City Water — Continued.*

[Bacteria per Cubic Centimeter.]

| DATE—1896.       | In River Water. | IN FILTERED WATER FROM |                   |                  |                            | Condition of Surface when Pumps were Stopped. | Loss of Head. Feet. |
|------------------|-----------------|------------------------|-------------------|------------------|----------------------------|-----------------------------------------------|---------------------|
|                  |                 | City Filter.           | Reservoir Outlet. | Tap at City Hall | Tap at Experiment Station. |                                               |                     |
| March 1, . . . . | -               | -                      | -                 | -                | -                          | Drained.                                      | -                   |
| 2, . . . .       | -               | -                      | -                 | -                | -                          | Drained.                                      | 4.3                 |
| 3, . . . .       | -               | -                      | -                 | -                | -                          | Drained.                                      | 5.0                 |
| 4, . . . .       | -               | -                      | -                 | -                | -                          | Covered.                                      | 5.9                 |
| 5, . . . .       | -               | -                      | -                 | -                | -                          | Covered.                                      | 5.4                 |
| 6, . . . .       | -               | -                      | -                 | -                | -                          | Covered.                                      | 6.6                 |
| 7, . . . .       | -               | 72                     | 65                | 85               | -                          | Covered.                                      | 7.8                 |
| 8, . . . .       | 5,200           | 97                     | -                 | -                | -                          | -                                             | -                   |
| 9, . . . .       | 5,200           | 97                     | 160               | 170              | 107                        | Drained.                                      | 6.8                 |
| 10, . . . .      | 6,500           | 84                     | 101               | 110              | 94                         | Covered.                                      | 7.9                 |
| 11, . . . .      | 11,400          | 93                     | 128               | 97               | 98                         | Covered.                                      | 8.0                 |
| 12, . . . .      | 8,800           | 110                    | 85                | 137              | 94                         | Covered.                                      | 7.9                 |
| 13, . . . .      | 6,700           | 139                    | 118               | 50               | 98                         | Drained.                                      | 7.9                 |
| 14, . . . .      | 5,400           | 166                    | 64                | 85               | 175                        | Drained.                                      | 7.8                 |
| 15, . . . .      | -               | -                      | -                 | -                | -                          | -                                             | -                   |
| 16, . . . .      | 8,300           | 358                    | 107               | 98               | -                          | Drained.                                      | 7.8                 |
| 17, . . . .      | 6,100           | 234                    | 108               | 116              | 118                        | Drained.                                      | 8.0                 |
| 18, . . . .      | 5,500           | 127                    | 90                | 70               | 143                        | Drained.                                      | 7.8                 |
| 19, . . . .      | 3,200           | -                      | 114               | 124              | 172                        | Covered.                                      | 7.8                 |
| 20, . . . .      | 9,200           | 88                     | 149               | 142              | 174                        | Drained.                                      | 7.7                 |
| 21, . . . .      | 7,100           | 63                     | 85                | 93               | 132                        | Covered.                                      | 8.0                 |
| 22, . . . .      | -               | -                      | -                 | -                | -                          | -                                             | -                   |
| 23, . . . .      | 4,200           | 314                    | 70                | 85               | 165                        | Drained.                                      | 6.0                 |
| 24, . . . .      | 3,000           | 44                     | 96                | 77               | 102                        | Covered.                                      | 7.8                 |
| 25, . . . .      | 3,000           | 41                     | 78                | 69               | 250                        | Drained.                                      | 7.8                 |
| 26, . . . .      | 1,200           | 36                     | 77                | 66               | 95                         | Drained.                                      | 7.9                 |
| 27, . . . .      | -               | -                      | 53                | 51               | 87                         | Covered.                                      | 8.0                 |
| 28, . . . .      | -               | -                      | -                 | -                | 128                        | Drained.                                      | 5.3                 |
| 29, . . . .      | -               | -                      | -                 | -                | -                          | Drained.                                      | 5.8                 |
| 30, . . . .      | 7,000           | 255                    | 80                | 99               | 93                         | Drained.                                      | 6.3                 |
| 31, . . . .      | 4,300           | 99                     | 292               | 98               | 101                        | Covered.                                      | 6.8                 |

*Daily Bacterial Results, Lawrence City Water — Concluded.*

[Bacteria per Cubic Centimeter.]

| DATE — 1896.     | In River Water. | IS FILTERED WATER FROM |                   |                   |                            | Condition of Surface when Pumps were Stopped. | Loss of Head. — Feet. |
|------------------|-----------------|------------------------|-------------------|-------------------|----------------------------|-----------------------------------------------|-----------------------|
|                  |                 | City Filter.           | Reservoir Outlet. | Tap at City Hall. | Tap at Experiment Station. |                                               |                       |
| April 1, . . . . | 7,600           | 50                     | 114               | 84                | 122                        | Drained.                                      | 6.5                   |
| 2, . . . .       | 6,100           | 56                     | 1,253             | 40                | 145                        | Covered.                                      | 6.8                   |
| 3, . . . .       | 3,300           | 56                     | 326               | 214               | 85                         | Covered.                                      | 7.0                   |
| 4, . . . .       | 2,800           | 98                     | 256               | 119               | 118                        | Covered.                                      | 5.7                   |
| 5, . . . .       | -               | -                      | -                 | -                 | -                          | Covered.                                      | -                     |
| 6, . . . .       | 2,800           | 63                     | 114               | 109               | 88                         | Covered.                                      | 4.9                   |
| 7, . . . .       | 3,200           | 44                     | 47                | 86                | 66                         | Covered.                                      | 5.3                   |
| 8, . . . .       | 2,300           | 51                     | 109               | 47                | 80                         | Drained.                                      | 6.5                   |
| 9, . . . .       | 1,800           | 27                     | 60                | 77                | 122                        | Drained.                                      | 3.6                   |
| 10, . . . .      | 8,600           | 30                     | 102               | 57                | 104                        | Drained.                                      | 6.4                   |
| 11, . . . .      | 4,900           | 38                     | 92                | 58                | 68                         | Covered.                                      | 5.8                   |
| 12, . . . .      | -               | -                      | -                 | -                 | -                          | -                                             | -                     |
| 13, . . . .      | 1,700           | 40                     | 33                | 58                | 30                         | Covered.                                      | 5.2                   |
| 14, . . . .      | 6,200           | 44                     | 46                | 46                | 59                         | Drained.                                      | 5.9                   |
| 15, . . . .      | 4,600           | 63                     | 52                | 47                | 35                         | Drained.                                      | 6.6                   |
| 16, . . . .      | 5,800           | 32                     | 55                | 45                | 42                         | Drained.                                      | 6.5                   |
| 17, . . . .      | 5,700           | 24                     | 19                | 36                | 37                         | Covered.                                      | 5.7                   |
| 18, . . . .      | 4,900           | 36                     | 34                | 33                | 46                         | Covered.                                      | 5.7                   |
| 19, . . . .      | -               | -                      | -                 | -                 | -                          | Covered.                                      | 4.9                   |
| 20, . . . .      | -               | -                      | -                 | -                 | -                          | Covered.                                      | -                     |
| 21, . . . .      | 2,200           | 45                     | 86                | 45                | 31                         | Covered.                                      | 4.3                   |
| 22, . . . .      | 2,900           | 6                      | 22                | 72                | 39                         | Covered.                                      | 5.2                   |
| 23, . . . .      | 2,300           | 16                     | 25                | 26                | 36                         | Drained.                                      | 6.2                   |
| 24, . . . .      | 2,300           | 25                     | 208               | 25                | 74                         | Drained.                                      | 6.3                   |
| 25, . . . .      | 3,900           | 25                     | 52                | 22                | 36                         | Covered.                                      | 5.6                   |
| 26, . . . .      | -               | -                      | -                 | -                 | -                          | Covered.                                      | -                     |
| 27, . . . .      | 2,600           | 32                     | 48                | 22                | 22                         | Covered.                                      | 4.9                   |
| 28, . . . .      | 3,300           | 43                     | 71                | 24                | 38                         | Drained.                                      | 6.3                   |
| 29, . . . .      | 1,300           | 29                     | 16                | 22                | 24                         | Drained.                                      | 7.0                   |
| 30, . . . .      | 1,700           | 18                     | 19                | 19                | 24                         | Drained.                                      | 6.2                   |

*Monthly Averages of Daily Bacterial Results from the Lawrence City Water.*

| MONTHS.                                                                                                             | BACTERIA PER CUBIC CENTIMETER IN WATER FROM |                           |                      |                   |                               |
|---------------------------------------------------------------------------------------------------------------------|---------------------------------------------|---------------------------|----------------------|-------------------|-------------------------------|
|                                                                                                                     | River.                                      | Effluent<br>at<br>Filter. | Reservoir<br>Outlet. | City Hall<br>Tap. | Experiment<br>Station<br>Tap. |
| <b>1895.</b>                                                                                                        |                                             |                           |                      |                   |                               |
| November, . . . . .                                                                                                 | 8,700                                       | 64                        | 56                   | 50                | 52                            |
| December, . . . . .                                                                                                 | 6,700                                       | 84                        | 64                   | 60                | 56                            |
| <b>1896.</b>                                                                                                        |                                             |                           |                      |                   |                               |
| January, . . . . .                                                                                                  | 7,500                                       | 166                       | 125                  | 88                | 74                            |
| February, . . . . .                                                                                                 | 12,600                                      | 315                       | 235                  | 166               | 140                           |
| March, . . . . .                                                                                                    | 5,900                                       | 138                       | 106                  | 96                | 127                           |
| April, . . . . .                                                                                                    | 3,800                                       | 40                        | 180                  | 57                | 63                            |
| Averages, . . . . .                                                                                                 | 7,533                                       | 134                       | 119                  | 86                | 85                            |
| Per cent. which the average number of bacteria<br>removed was of the average number of river<br>bacteria, . . . . . | -                                           | 98.22                     | 98.42                | 98.86             | 98.87                         |

It must be remembered that these results and the final averages are of the six months of the year when the bacterial efficiency of this uncovered filter is lowest.



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**METHODS EMPLOYED**

**AT THE**

**LAWRENCE EXPERIMENT STATION**

**FOR THE**

**QUANTITATIVE DETERMINATION OF BACTERIA**

**IN SEWAGE AND WATERS.**

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By **GEORGE W. FULLER** and **WILLIAM R. COPELAND.**

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# METHODS EMPLOYED AT THE LAWRENCE EXPERIMENT STATION FOR THE QUANTITATIVE DETERMINATION OF BACTERIA IN SEWAGE AND WATERS.

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By GEORGE W. FULLER and WILLIAM R. COPELAND.

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In this paper it is proposed to record briefly the methods which have been employed recently in the determination of the number of bacteria in sewage and waters. It is also desired to point out certain modifications which have been made since the methods were originally described in the report of the State Board of Health upon the purification of sewage and water (1), and further, to present the evidence on which the more important changes were based.

The principal topics treated in this paper are noted in the following outline : —

1. Collection and storage of samples.
2. Preparation of culture media.
3. Sterilization and storage of culture media.
4. Technique of plating.
5. Technique of counting colonies of bacteria on plates.
6. Effect of length of period of cultivation and of temperature at which cultivation takes place.
7. Comparison of the relative values of gelatine and glycerine agar for quantitative bacterial work.
8. Roll cultures in four liter bottles.

## *Collection and Storage of Samples.*

The samples of sewage, etc., for bacterial analysis are collected in mushroom ground-glass stoppered bottles of a capacity of about one ounce. Special care has been taken to procure a glass stopper with a mushroom top rising about half an inch from the top of the bottle. This form of stopper protects the mouth of the bottle from becoming contaminated by the fingers in removing the sterilized

bottle from its tin case. The bottles (especially new ones) are soaked for several hours in a solution of potassium permanganate and caustic soda. In fact, all glassware is treated with this solution before it is sterilized in order to remove all trace of organic matter; otherwise, organic matter contained in the bottle might serve as a food material for the bacteria present in the water to be analyzed and so allow them to multiply.

After treatment with permanganate, the bottles are rinsed in a dilute solution of sulphuric and oxalic acids. These acids remove the excess of permanganate and neutralize the free alkali. It is necessary to use much care in washing the bottles with water in order to remove all acid and to obtain as a result a sample bottle which is chemically clean. After cleaning and drying, the bottles, carefully stoppered, are placed in covered tin boxes made to fit the bottles approximately. The encased bottles and other glassware are then sterilized in an oven over a gas stove at a temperature of 160 degrees C. for an hour and a half.

When samples of sewage or water have been collected in such bottles they are placed in the ice compartment of a refrigerator, where, at a temperature of from 5 to 10 degrees C., they may be left for several hours without change. It should be noted here that samples collected out of town are not generally taken to the laboratory before plating, but are plated on the spot by the collector.

### *Preparation of Culture Media.*

Until July, 1894, nutrient gelatine was employed as the regular culture medium for quantitative bacterial work. Since July, 1894, nutrient glycerine agar has been used instead of nutrient gelatine. In addition to gelatine and glycerine agar, a solution composed of one-tenth of one per cent. of peptone and two-tenths of one per cent. of powdered glucose in sterilized tap water has been used to obtain a pure culture of *Bacillus prodigiosus*. A measured quantity of this solution, seeded with this specific germ, has been applied from time to time to the several experimental water filters, as described on page 598.

The ingredients used have been of as high a grade as could be obtained from the best dealers. Meat infusions were made, prior to July, 1892, by allowing one pound of finely chopped lean meat to digest in one liter of cold water for about twenty hours. The

infusions were filtered while cold. This treatment removed almost all of the fat globules, while the filtrate contained the various other substances extracted from the meat. From July, 1892, to January, 1894, meat infusions were made by allowing one pound (about four hundred and fifty grams) of finely chopped lean meat to digest in one liter of warm tap water for two hours; they were then heated for thirty minutes in a bath of boiling water, boiled for ten minutes over a free flame, and filtered, while hot, to remove the particles of meat, fat and coagulated albumen. In January, 1894, it was decided to return to the original method of digesting the meat in cold water for the reasons which will appear beyond.

Until Dec. 15, 1894, Witte's peptone was used. Since Dec. 15, 1894, Merck's "Peptonum Siccum" has been used instead of Witte's. The leaf gelatine used is made by Comte Fils, and labelled "Best French Brand." Agar free from acid has been used, and the glycerine has been twice distilled. The powdered glucose used is a high-grade commercial product. Common table salt has been used in the proportion described in the original formula of Koch, apparently with the view to aid in dissolving ingredients of nutrient culture media.

Nutrient gelatine is prepared by adding to one liter of meat infusion one per cent. by weight of peptone, one-half of one per cent. of salt and ten per cent. of gelatine. After weighing the dish containing these substances it is placed in a bath of boiling water and stirred constantly for ten minutes. By this time the gelatine and peptone are dissolved, and, after replacing the water which has evaporated as shown by loss in weight, five cubic centimeters of the solution are placed in a porcelain evaporating dish containing fifty cubic centimeters of distilled water. It has been the custom to boil this solution for three minutes over a free flame in order to expel carbon dioxide and free ammonia which may have been present. These gases, otherwise, would interfere with the accuracy of the titration with phenolphthalein, which is used as an indicator in the determination of the acidity of the solution. After boiling for three minutes, one cubic centimeter of phenolphthalein (five grams of powder in one liter of fifty per cent. alcohol) is added, and while the solution is still hot, enough twentieth normal caustic soda added from a burette to produce a slight pink color. By this method it is possible to determine accurately the acidity of the solution (2).

Experience has shown that the acidity of gelatine solutions is so

great at this point that it is necessary to add from fifty-five to seventy cubic centimeters of normal caustic soda solution to one liter of gelatine in order to neutralize the acid present, when phenolphthalein is used as an indicator. It should be noted here that the scale adopted at the Lawrence Experiment Station is based on the number of cubic centimeters of normal caustic soda which must be added to one liter of solution to produce a neutral reaction with phenolphthalein.

The amount of acid found in the solution varies with the composition of the meat infusion, peptone and gelatine employed (2).

When the degree of acidity has been determined enough normal caustic soda is added to the solution to reduce the acidity of the entire volume to a point which is slightly alkaline to blue litmus paper if Schultz's method is to be employed in the preparation of gelatine, or slightly alkaline to phenolphthalein if Timpe's method is followed. These two methods of procedure are described beyond.

The advantage of allowing the meat to remain for twenty hours in water in an ice-chest, and of filtering the meat infusion while cold, now becomes apparent because the albumens left in the meat infusion serve as a coagulant in place of egg albumen, which, following the practice described in text books, is customarily added at this time to replace the albumens precipitated and removed from the solution by filtration if the infusion is extracted with boiling water.

When the alkali has been mixed thoroughly with the solution the dish is placed in a bath of boiling water for twenty minutes. After this the dish is removed from the water bath and set over a free flame for five minutes with constant stirring; by this treatment the solution is brought to a boil for two minutes, to aid in making it clear. After adding enough boiling water to replace the water which has evaporated, five cubic centimeters of the solution are again titrated as described above. The degree of reaction changes slightly during the process of heating. Owing to changes in some of the ingredients the solution becomes a little more acid (from three to five cubic centimeters of normal acid per one liter). The next step in the process is to filter the solution rapidly through coarse flannel and absorbent cotton. To the filtrate it is necessary to add enough normal acid or alkali to produce the required degree of reaction. The gelatine is then placed in sterilized test-tubes (five cubic centimeters in each tube) and the tubes plunged at once

into cold water until the gelatine has solidified. These tubes are then sterilized in an Arnold steam sterilizer for thirty minutes on each of three consecutive days, or in an autoclave at a pressure of one atmosphere for from five to seven minutes.

Nutrient agar is prepared by adding to one liter of meat infusion, peptone and salt as in the preparation of gelatine, and one and three-tenths per cent. by weight of finely chopped agar. The remaining steps in its preparation are similar to those already described for gelatine, except that it is the custom to boil agar slowly for one hour over a free flame. To assist the process of dissolving the agar, five hundred cubic centimeters of water are added to the original volume of one liter before heat is applied.

Agar itself has been found to be neutral to phenolphthalein, therefore, the reaction of the solution is much lower at this point than a solution of gelatine would have been. The total acidity of the solution at this point ranges from thirty-five to forty-five cubic centimeters of normal acid per liter.

After titration and addition of normal alkali the agar is placed over a free flame and boiled slowly for two hours. In order to keep conditions of temperature and volume as nearly constant as possible during this process, boiling water is added from time to time to replace the water which has evaporated. When the agar has been heated for two hours and has been restored to its original volume it is filtered and titrated. The reaction of the medium changes very little during this process of heating. To the filtrate six per cent. by weight of twice-distilled glycerine is added, the solution titrated and enough normal acid or alkali put in to produce the required reaction. The solution is then tubed and placed in cold water. As agar does not lose its power to solidify even though heated for a long period of time, it has been the custom to sterilize it in the Arnold steam sterilizer for one hour on each of three consecutive days. Since June, 1895, it has been the custom to sterilize it in an autoclave for fifteen minutes at a pressure of one atmosphere.

As noted above, both Witte's and Merck's peptones have been used in these investigations, and Merck's has been employed during the present year. Experiments have shown that the composition of peptones influences somewhat the bacterial results, as has been described in an article published elsewhere (2) (8).

The present supply of Merck's peptone is found to be very satisfactory.

Reference has already been made to Schultz's (3) and Timpe's methods of alkalization. Schultz's method affords a more accurate means than the method originally described by Koch of carrying out the general procedure, and has been followed almost from the outset in the preparation of nutrient culture media. In brief, this method consists of adding enough normal alkali to an acid solution of a nutrient medium to reduce the acidity before heating to the degree which it is desired to maintain in the nutrient medium for plating. Timpe's (4) method consists of adding enough normal alkali to reduce the acidity before heating to the neutral point (phenolphthalein being used as an indicator) and the addition after heating of enough normal acid or alkali to the filtrate to produce the desired degree of reaction.

Until the middle of the year 1891 the method ordinarily described in text-books was followed. From July 1, 1891, to Jan. 1, 1895, Schultz's method was used at this laboratory, but it was then decided to change to Timpe's method because it appeared that by making the medium neutral each time before cooking, the chemical changes which take place proceed always under conditions which are more nearly parallel. Experience at this laboratory indicates that the final degree of reaction may be obtained more easily and more accurately by adding a definite number of cubic centimeters of normal acid or alkali to a liter of neutral culture medium, as described in Timpe's method, than by reducing the acidity to the required degree after the first heating, according to Schultz's method, because in the latter case the reaction seems to change during the subsequent process of preparation.

In this connection it should be noted that the degree of reaction has a decided effect on the development of the number of colonies on plates. Mr. J. J. Mackensie finds that (5) for Toronto tap water a nutrient gelatine neutral to phenolphthalein is most favorable. Dr. Johnston (6) found that nutrient gelatine with reaction which corresponds to No. 20 on this scale was favorable. This matter has been discussed in detail in an article published elsewhere, but in order to bring out the great importance of this subject the following table is again presented (2) :—

*Table showing a Comparison of Representative Results of the Quantitative Determination of Bacteria in Lawrence Sewage, Merrimack River Water and Lawrence City (Filtered) Water on Gelatine of Different Degrees of Reaction, but with other Conditions the same.*

| REACTION.*     | LAWRENCE SEWAGE.               |                                                                     | MERRIMACK RIVER WATER.         |                                                                     | LAWRENCE CITY WATER (FILTERED). |                                                                     |
|----------------|--------------------------------|---------------------------------------------------------------------|--------------------------------|---------------------------------------------------------------------|---------------------------------|---------------------------------------------------------------------|
|                | Bacteria per Cubic Centimeter. | Percentage which Numbers are of that obtained with Reaction No. 20. | Bacteria per Cubic Centimeter. | Percentage which Numbers are of that obtained with Reaction No. 20. | Bacteria per Cubic Centimeter.  | Percentage which Numbers are of that obtained with Reaction No. 20. |
| 40, . . . . .  | 168,000                        | 6                                                                   | 100                            | 1                                                                   | 4                               | 2                                                                   |
| 35, . . . . .  | 448,000                        | 16                                                                  | 400                            | 3                                                                   | 7                               | 3                                                                   |
| 30, . . . . .  | 1,225,000                      | 45                                                                  | 600                            | 4                                                                   | 16                              | 8                                                                   |
| 25, . . . . .  | 1,720,000                      | 64                                                                  | 7,800                          | 55                                                                  | 84                              | 46                                                                  |
| 20, . . . . .  | 2,688,000                      | 100                                                                 | 15,000                         | 100                                                                 | 184                             | 100                                                                 |
| 15, . . . . .  | 2,870,000                      | 106                                                                 | 13,300                         | 89                                                                  | 169                             | 92                                                                  |
| 10, . . . . .  | 2,726,000                      | 101                                                                 | 8,100                          | 54                                                                  | 112                             | 60                                                                  |
| 5, . . . . .   | 2,625,000                      | 98                                                                  | 6,900                          | 46                                                                  | 80                              | 43                                                                  |
| 0, . . . . .   | 2,234,000                      | 86                                                                  | 5,800                          | 38                                                                  | 66                              | 35                                                                  |
| -5, . . . . .  | 2,342,000                      | 87                                                                  | 4,000                          | 26                                                                  | 58                              | 31                                                                  |
| -10, . . . . . | 2,230,000                      | 82                                                                  | 3,200                          | 21                                                                  | 48                              | 26                                                                  |
| -15, . . . . . | 1,470,000                      | 54                                                                  | 1,300                          | 9                                                                   | 29                              | 15                                                                  |
| -20, . . . . . | 1,290,000                      | 48                                                                  | 500                            | 3                                                                   | 15                              | 8                                                                   |
| -25, . . . . . | 1,520,000                      | 56                                                                  | 200                            | 1                                                                   | 13                              | 7                                                                   |

\* Numbers refer to cubic centimeters of normal acid or alkali which must be added to a liter of nutrient medium in order to make it neutral to phenolphthalein. Minus (-) means an alkaline solution.

Following the custom practised in this laboratory the reaction of a solution which contains twenty cubic centimeters of normal acid in one liter is known as reaction No. 20. In connection with the preceding table it should be noted that reactions Nos. 18 to 20 were used in the laboratory from 1891 to 1895. The exact degree of reaction was determined at that time by titrating one cubic centimeter of the solution in five cubic centimeters of water. Since January, 1895, reactions Nos. 15 to 18 have been used; and the reaction has been determined by titrating five cubic centimeters of the solution in fifty of water, as already described.

As a result of these experiments it may be said that reactions Nos. 13 to 20 have been found to produce the development of the maximum number of bacteria.

The evidence at hand shows that the degree of reaction which is most favorable for bacterial growth varies somewhat with different



species of bacteria, with bacteria of different degrees of vitality but of the same species (9), and perhaps with the seasons of the year. A factor which should not be neglected is the variable amount of muscle sugar present in different meat infusions, as first pointed out by Dr. Theobald Smith (7). In view of these facts, therefore, reaction No. 18 cannot be said to be the optimum under all conditions, though it seems to come nearest to the optimum reaction so far as Lawrence conditions are concerned. The need and value of a uniform standard degree of reaction is insisted upon, however, for the sake of getting comparable results.

### *Sterilization and Storage of Culture Media.*

Gelatine has been sterilized for thirty minutes on each of three successive days in an Arnold steam sterilizer. It has often been noted, however, that gelatine plates would not solidify, especially in summer weather, and showed evident signs of contamination when sterilized in this manner. To obtain nutrient media which should be sterile every time and to avoid delay caused by heating on three days in succession, an autoclave was obtained in June, 1895. It has been necessary, at the station, to generate steam within the autoclave itself, and this extra heating tends to destroy the power of gelatine to solidify. Agar, and water for purposes of dilution, can be sterilized satisfactorily, however, and at the present time they are always sterilized in this manner.

In order to keep media in good condition a lot of two liters is made up at least once in two weeks, tubed and placed in the ice-chest. To make certain that the media are sterile they are heated for ten minutes in boiling water just before use for plating.

### *Technique of Plating.*

The technique of plating as applied to the bacterial analysis of water consists of mixing a measured amount of the samples of water with a certain amount of gelatinous nutrient medium, with proper precautions, in a Petri double dish, well known to bacteriologists. The method pursued in plating is as follows; after shaking thoroughly the glass bottle (described on page 585) containing the sample of water to be analyzed, one cubic centimeter is drawn out in a pipette graduated to discharge this quantity of water. This measured amount is discharged into a tube of melted nutrient medium (gelatine or agar), and after it has been thoroughly mixed with the food material the contents of the tube are poured into a sterile Petri

dish. As the solution enters the dish it is spread uniformly over the surface and allowed to solidify.

The previous shaking and mixing in the tube divides the bacteria from one another, and, as they lie scattered in the film over the surface of the plate, they are kept separate by the gelatinization of the medium. Under these favorable conditions each cell multiplies by fission and forms an independent colony.

*Technique of Counting Colonies of Bacteria on Plates.*

Since each bacterium is supposed to be in isolation, and in a position where it may multiply by cell division until a colony is formed, the actual number of individual bacteria which existed in one cubic centimeter of the original sample of water may be determined by counting these colonies. To facilitate the process of counting it is necessary to use special care in spreading the liquid medium in order to obtain a film as nearly uniform in thickness as possible over the whole surface of the plate. When so prepared it is possible to count accurately each colony on a plate containing eight hundred colonies, by the aid of a hand lens and a glass plate ruled with two sets of lines, forming squares one square centimeter in area (Wolffhügel's apparatus).

As the number of colonies increases to three thousand, other methods are employed, such as counting a diametrical section of the plate one centimeter in width. If the colonies on a plate amount to ten thousand or more it is customary to count only those bacteria which lie in three or more areas one centimeter square; these areas must be chosen with care so as to represent an average of the thick, medium and thin portions of the plate. As errors may easily creep in by counting areas which are not average examples of such portions of a plate, it is necessary that much care be taken to select representative areas.

It is essential that the temperature of the melted culture medium should be kept below 39° C. in order to prevent bacteria in the vegetative state from being killed by the heat of the solution. For the purpose of securing a uniform and satisfactory temperature when working with agar it is the custom to have the melted agar kept liquid for one hour before plating, in a water bath maintained at a temperature of 39° C. by an automatic regulator. On the other hand, the temperature of the melted tubes of culture media should not be allowed to become so low that the medium can-

not be poured from the tube readily. At best about five per cent. of the contents remain in the tube after pouring. As long as this percentage is kept constant the results are strictly comparable, although they do not comprise the entire contents of the cubic centimeter of water drawn from the sample for plating.

As Lawrence sewage often contains more than two million bacteria per cubic centimeter, in order to facilitate the estimation of the number of colonies, it is customary to reduce the number which otherwise would appear on a plate by mixing one cubic centimeter of the sample in a flask containing five hundred cubic centimeters of sterilized tap water; the flask is then well shaken, one cubic centimeter taken out and plated in the usual manner. Other samples of water, which contain five thousand or more bacteria in a cubic centimeter, are diluted in the ratio of one to one hundred by a similar process.

When the medium has become solid the plate is placed in a 20° C. thermostat to allow the colonies of bacteria to develop. Agar plates are inverted, to prevent the water of condensation from running over the surface of the medium, otherwise colonies of bacteria which lie on the surface would spread, together with this water, over the surface of the plate.

Agar plates stand in the thermostat for four days; but as certain bacteria peptonise or liquefy gelatine it is necessary to remove some gelatine plates to an ice-chest after forty-eight or sixty hours' growth. The cold temperature checks to a considerable degree the development of liquefying colonies but allows time for the further development of bacteria, which grow slowly.

Owing to the obliteration of small colonies, either by a thick film of bacteria which sometimes spreads over the surface of the medium or by liquefaction of the gelatine, it is possible that error may be introduced in the calculation of the number of colonies on a plate. It is necessary, therefore, to examine frequently and perhaps to count plates which contain such colonies before the normal time for development has expired.

*Effect of Length of Period of Cultivation and of Temperature at which Cultivation takes Place.*

The length of time during which a plate is allowed to develop and the temperature of the chamber in which the plates stand produce a marked effect on the number of colonies which will develop.

*Table showing the Number of Colonies per Cubic Centimeter which had developed on a Plate at Different Periods of Growth.*

| SOURCE OF SAMPLE.                        | BACTERIA PER CUBIC CENTIMETER. |           |           |           |
|------------------------------------------|--------------------------------|-----------|-----------|-----------|
|                                          | TEMPERATURE, 20 DEGREES C.     |           |           |           |
|                                          | 1 Day.                         | 2 Days.   | 3 Days.   | 4 Days.   |
| Canal water (Merrimack River), . . . . . | 913                            | 8,613     | 12,317    | 15,017    |
| City (filtered) water, . . . . .         | 8                              | 48        | 72        | 87        |
| Effluent from Filter No. 3 B, . . . . .  | 0                              | 24        | 53        | 64        |
| Sewage, . . . . .                        | 50,000                         | 4,000,000 | 4,579,000 | 4,801,000 |
| Effluent from Filter No. 5, . . . . .    | 100                            | 400       | 900       | 1,300     |

*Table showing the Number of Colonies of Bacteria per Cubic Centimeter which developed on Plates at Different Degrees of Temperature.*

| SOURCE OF SAMPLE.                | BACTERIA PER CUBIC CENTIMETER.    |         |         |         |        |         |         |         |        |         |         |         |
|----------------------------------|-----------------------------------|---------|---------|---------|--------|---------|---------|---------|--------|---------|---------|---------|
|                                  | TEMPERATURE (DEGREES CENTIGRADE). |         |         |         |        |         |         |         |        |         |         |         |
|                                  | 20.                               |         |         |         | 30.    |         |         |         | 37.    |         |         |         |
|                                  | 1 Day.                            | 2 Days. | 3 Days. | 4 Days. | 1 Day. | 2 Days. | 3 Days. | 4 Days. | 1 Day. | 2 Days. | 3 Days. | 4 Days. |
| Canal water, . . . . .           | 3.200                             | 14.400  | 17.100  | 18.200  | 8.400  | 15.100  | 17.700  | 18.100  | 8.800  | 11.500  | 12.200  | 12.700  |
| City (filtered) water, . . . . . | 3                                 | 62      | 83      | 89      | 30     | 71      | 76      | 82      | 28     | 36      | 41      | 44      |

NOTE.—These numbers are averages, in each instance, of sixteen sets of determinations made on separate days in June and July, 1895; all of the plates comprising a set on any special day having been made from a single sample of canal or city water.

Experiments have been made to test the effect produced by allowing plates to develop for a longer period. The power which some bacteria possess to liquefy gelatine or to form an opaque growth over a considerable portion of agar often makes it impossible to keep plates more than four days. An increase has been noted, however, in several instances when plates were allowed to develop for ten days. As the work at Lawrence calls for many plates containing liquefying and spreading colonies it has been thought best to adopt a rule which should secure, for purposes of comparison, counts of plates under conditions as nearly parallel as possible. For this reason plates have always been counted on the fourth day. It sometimes happens, however, that plates which have been partially liquefied or contain spreading colonies present a smaller number of colonies on the fourth than on the third day. Under such conditions the highest number has been taken.

*Comparison of the Relative Value of Gelatine and Glycerine Agar for Quantitative Bacterial Work.*

Work at the Lawrence Experiment Station often has to deal with samples of sewage and water which contain large numbers of bacteria. Many of these bacteria liquefy gelatine plates. The nutrient gelatine itself has been found to melt if the plates are allowed to stand a short time on the laboratory table in hot weather, thereby causing the value of counts on gelatine plates to be much impaired. As the gelatine did not melt in cold weather it was possible to count the bacteria more accurately, and therefore determinations made at different seasons of the year were not as comparable as desired. Reference has already been made to the difficulty experienced in sterilizing gelatine.

Glycerine agar was found as a result of long experiment to be a medium which would give a maximum number of colonies at all seasons of the year, a medium in which sewage bacteria could grow rapidly without being able to liquefy it, and a medium which could be heated in our autoclave until sterile without losing its power of solidification. Moreover, it was found that, by careful observation of necessary precautions, agar would give results which compared favorably with gelatine and often gave better results than gelatine in summer. For these reasons it was decided to substitute glycerine agar for gelatine in a considerable portion of the work, while making frequent control cultures with ordinary nutrient gelatine.

*Table showing a Comparison of the Number of Bacteria per Cubic Centimeter obtained from Gelatine and Glycerine Agar.*

| DATE.          | SEWAGE.   |                 | EFFLUENT FROM SEWAGE FILTERS. |                 | CANAL WATER. |                 | EFFLUENT FROM CANAL WATER FILTERS. |                 |
|----------------|-----------|-----------------|-------------------------------|-----------------|--------------|-----------------|------------------------------------|-----------------|
|                | Gelatine. | Glycerine Agar. | Gelatine.                     | Glycerine Agar. | Gelatine.    | Glycerine Agar. | Gelatine.                          | Glycerine Agar. |
| <b>1894.</b>   |           |                 |                               |                 |              |                 |                                    |                 |
| January, . . . | 749,000   | 731,000         | -                             | -               | 7,800        | 5,500           | 56                                 | 45              |
| March, . . .   | 586,000   | 563,000         | -                             | -               | 1,737        | 1,683           | 62                                 | 62              |
| July, . . .    | -         | -               | -                             | -               | -            | -               | 85                                 | 126             |
| <b>1895.</b>   |           |                 |                               |                 |              |                 |                                    |                 |
| November, . .  | 3,077,000 | 2,812,000       | -                             | -               | 8,500        | 7,100           | 61                                 | 68              |
| December, . .  | 6,400,000 | 6,200,000       | 440,400                       | 394,000         | 11,900       | 10,700          | 58                                 | 57              |
| <b>1896.</b>   |           |                 |                               |                 |              |                 |                                    |                 |
| January, . . . | 2,150,000 | 1,995,000       | 287,000                       | 238,000         | 9,500        | 9,600           | 34                                 | 43              |
| March, . . .   | 2,495,000 | 2,135,000       | 179,000                       | 149,000         | 5,950        | 6,150           | 85                                 | 87              |
| May, . . .     | 4,490,000 | 4,630,000       | 251                           | 269             | 5,200        | 5,500           | 34                                 | 34              |

NOTE.—The numbers given in this table are averages of numerous determinations. The plates were allowed to develop from three to four days. The low numbers given in certain instances for gelatine plates are due to liquefaction of the gelatine.

It was known that results were sometimes higher on gelatine than on glycerine agar, as indicated in this table, and that the development on the former medium is somewhat more rapid, but it was believed that glycerine agar under the actual conditions gave results which for all seasons of the year were more nearly comparable. Numerous comparative results have been obtained at frequent intervals, and the earlier data have been confirmed in a general way.

### *Roll Cultures in Four-liter Bottles.*

Reference has already been made to the use of peptone glucose solutions (one-tenth per cent. peptone and two-tenths per cent. of glucose in tap water) containing a pure culture of *Bacillus prodigiosus* for testing the efficiency of sand filters. A measured quantity of the solution containing large numbers of this germ is mixed with the water on the surface of the filter. The amount of solution applied varies with the area of the filter, rate of filtration and other conditions. As this bacillus has not been found to occur naturally in Lawrence waters it is used to test the power of filters to remove bacteria, because any *B. prodigiosus* cells which appear in the effluent must have passed through the sand in the filter. Further, it has been learned by numerous experiments that this germ does not grow within filters, and in this respect it differs from many common water bacteria and resembles the germ of typhoid fever. Still another advantage in the use of *B. prodigiosus* lies in the ease with which it may be identified. By the determination of the exact number of cells of *Bacillus prodigiosus* applied and the number which appear in the effluent it is possible to obtain valuable tests upon the efficiency of the filter both quantitatively and qualitatively.

The effluent of some of the Lawrence experimental water filters amounts to twenty thousand gallons of water in a day. It is impossible to examine all of such effluents and yet it is desirable to test them as thoroughly as possible. This is usually done by taking samples at frequent intervals during the day. But in the application of *B. typhosus* and *B. prodigiosus* to many of the filters it has been found that a large number of the plates seeded with one cubic centimeter of effluent do not contain any of those specific germs which have been added to the water as it enters the filter. In other words, there are fewer than one bacteria of this kind per cubic centimeter. Circumstances have been such that it has been desirable to study more thoroughly the presence of the specific germ in the effluent, and to learn, for

instance, whether the average number would be 0.1 or 0.01 per cubic centimeter. To accomplish this purpose fifty cubic centimeters of effluent are mixed with one hundred cubic centimeters of gelatine (twenty per cent. of gelatine in one liter) in a four-liter bottle. By rolling the bottle as it lies on its side on a cake of ice the fifty cubic centimeters mixed together with the gelatine are distributed over the large inner surface of the bottle.

The advantage of using this method to test waters for a certain species is great when the total number of bacteria is small, because it is possible to analyze a large number of cubic centimeters of effluent at one time and yet have the single colonies isolated.

*Table showing Results of Examinations by Roll Table Method for Bacillus Prodigiosus in the Effluent of Water Filters.*

| DATE—1895. |               | Number of Filter. | Depth of Filter. (Inches.) | <i>Bacillus Prodigiosus</i> applied per Cubic Centimeter. | Quantity of Effluent examined (Cubic Centimeters). | Number of Colonies of <i>Bacillus Prodigiosus</i> found. |
|------------|---------------|-------------------|----------------------------|-----------------------------------------------------------|----------------------------------------------------|----------------------------------------------------------|
| September  | 2, . . . . .  | 7 A               | 24                         | 347                                                       | 50                                                 | 0                                                        |
|            | 2, . . . . .  | 3 B               | 60                         | 347                                                       | 50                                                 | 0                                                        |
|            | 2, . . . . .  | 3 B               | 60                         | 347                                                       | 50                                                 | 0                                                        |
|            | 2, . . . . .  | 3 B               | 60                         | 424                                                       | 50                                                 | 0                                                        |
|            | 8, . . . . .  | 7 A               | 24                         | 424                                                       | 50                                                 | 3                                                        |
|            | 8, . . . . .  | 8 A               | 60                         | 424                                                       | 50                                                 | 0                                                        |
|            | 8, . . . . .  | 3 B               | 60                         | 382                                                       | 50                                                 | 0                                                        |
|            | 7, . . . . .  | 7 A               | 60                         | 882                                                       | 50                                                 | 5                                                        |
|            | 7, . . . . .  | 8 A               | 60                         | 382                                                       | 50                                                 | 0                                                        |
|            | 23, . . . . . | 3 B               | 60                         | 429                                                       | 60                                                 | 0                                                        |
|            | 23, . . . . . | 8 A               | 60                         | 429                                                       | 50                                                 | 0                                                        |
| October    | 2, . . . . .  | 3 B               | 60                         | 376                                                       | 50                                                 | 0                                                        |
|            | 2, . . . . .  | 8 A               | 60                         | 376                                                       | 80                                                 | 0                                                        |
|            | 7, . . . . .  | 3 B               | 60                         | 565                                                       | 50                                                 | 0                                                        |
|            | 7, . . . . .  | 8 A               | 60                         | 565                                                       | 50                                                 | 0                                                        |
|            | 8, . . . . .  | 8 B               | 60                         | 329                                                       | 50                                                 | 0                                                        |
|            | 8, . . . . .  | 8 A               | 60                         | 329                                                       | 50                                                 | 0                                                        |

#### REFERENCES.

- (1) Special Report of the Massachusetts State Board of Health, 1890, p. 811.
- (2) Fuller, Journal of American Public Health Association, 1895, Vol. XX, pp. 381-399.
- (3) Schultz, Centralblatt für Bacteriologie, 1891, X, 53.
- (4) Timpe, Centralblatt für Bacteriologie, XIV, XV, XVII.
- (5) Mackensie, Journal of American Public Health Association, 1895, Vol. XX, p. 427.
- (6) Johnston, Journal of American Public Health Association, 1895, Vol. XX, p. 478.
- (7) Smith, Wilder Quarter-Century Book, 1893, p. 195.
- (8) Sedgwick and S. C. Prescott, Journal of American Public Health Association, Vol. XX, 1895, pp. 450-458.
- (9) Fuller, Annual Report of the Massachusetts State Board of Health, 1891, pp. 638-644.

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# SEWAGE PURIFICATION

OF

CITIES AND TOWNS IN MASSACHUSETTS.

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## SEWAGE PURIFICATION OF CITIES AND TOWNS IN MASSACHUSETTS.

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In order to learn the results obtained by the systems of sewage disposal in the cities and towns in Massachusetts which have adopted a method of sewage purification, the State Board of Health since 1892 has caused chemical analyses to be made of sewage and effluent from many of the systems now in operation.

The results for the year 1892 were printed in connection with a paper upon the "Sewage disposal of cities and towns in Massachusetts by intermittent filtration," in the annual report of the State Board of Health for that year, containing chemical analyses of the sewage and effluent from the works at the three places described, viz., Framingham, Marlborough and Gardner. In the annual report of the Board for the year 1893 there appeared a corresponding paper, in which were given the results of analyses of sewage and effluent up to Jan. 1, 1894, from these three and several additional sewage-purification plants, together with a brief description of each of the systems.

In the present paper will be found analyses made during the years 1894 and 1895 of the sewage and effluents from the works at Amherst, Brockton, Framingham, Gardner, Marlborough and Medfield. A short description of the works at each place is given in connection with the analyses, and in some cases statements made in previous reports are repeated.

The first plant for the disposal of town sewage by filtration in Massachusetts was constructed at Lenox in 1876. A system for the disposal of the sewage of a portion of the town of Amherst, partly by filtration but chiefly by irrigation, was constructed about 1881, and a small system for the disposal of sewage by intermittent filtration was introduced at Medfield in 1886. Since the last date the towns of Framingham, Gardner and Westborough and the cities of Marlborough and Brockton have constructed and are now operating works for the disposal of sewage by intermittent

filtration, and a new disposal field has been constructed and is in use at Lenox. At North Brookfield there is a small system of sewage disposal by irrigation and filtration. There are also in the State several large institutions which dispose of their sewage by intermittent filtration.

The sewage of the city of Worcester is treated with chemicals, and the method has been fully described under "Blackstone River," in the chapters on the examination of rivers in previous reports of the Board, and on page 367 of this volume. Analyses made by the chemists at Worcester, showing the results obtained at the chemical precipitation works there, have already been given on page 372 of the report for 1894 and on page 360 of the present report.

In addition to the analyses given in the following pages, there have also been collected hourly samples of sewage, representing the entire flow for twenty-four hours in the main sewers at Framingham, Gardner, Marlborough and the Worcester Lunatic Asylum. The results of chemical and bacterial analyses of these samples have been presented and discussed in the chapter on the composition of sewage, in the report of the investigation upon the purification of sewage at the Lawrence experiment station, on page 462 of the annual report for 1894 and on page 452 of this volume.

#### SEWAGE DISPOSAL AT AMHERST.

The population of the town in 1895 was 4,785. Sewerage facilities have been provided only for portions of the main village, and the sewage is disposed of by two systems.

The first system, begun in 1881 and subsequently extended, collects the sewage from about 1,000 persons. The system is of the so-called "separate" type, which provides for house sewage only. The sewage flows to a settling tank about a mile south-east of the village, and thence through a pipe 520 feet long into Fort River. The settling tank into which it discharges has two compartments, each 10 feet wide, 15 feet long and 6 feet deep, constructed of stone laid in cement. The main sewer, which is 10 inches in diameter, branches just before it enters the tank, so that the sewage may be diverted into either compartment separately, delivering it at the surface of the sewage in the tank, which is about 1 foot below the top of the tank. The sewage is not screened, but the mouth of the outlet pipe turns downwards below the surface of

the sewage, so that some of the floating matter is retained in the tank. At irregular intervals the sludge is removed and mixed with soil, to be used as a fertilizer on the adjoining fields.

In the annexed table are the results of analyses of sewage before and after passage through the tank. It is to be noted that the effluent appears to represent sewage more dilute than that collected from the inlet pipe, so that the apparent purification was probably greater than that which actually took place. Analyses are also given of Fort River above and below the point of discharge of the effluent pipe.

The second system, which was begun in 1886, takes the sewage from a part of the thickly populated portion of the town, north of the town hall, to a settling tank and irrigation field half a mile north of the village. A description of this system, with results of analyses of sewage and effluent, was presented in the annual report for 1893. No analyses of the sewage or effluent have been made since that time.

*Chemical Examination of Sewage from Amherst.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.      |           |        | RESIDUE ON EVAPORATION. |            |            |                   |            |            |
|---------|---------------------|------------------|-----------|--------|-------------------------|------------|------------|-------------------|------------|------------|
|         |                     | Turbidity.       | Sediment. | Color. | TOTAL RESIDUE.          |            |            | LOSS ON IGNITION. |            |            |
|         |                     |                  |           |        | Total.                  | Dissolved. | Suspended. | Total.            | Dissolved. | Suspended. |
|         | 1894.               |                  |           |        |                         |            |            |                   |            |            |
| 11654   | Jan. 18.            | Decided, milky.  | Heavy.    | 0.70   | 19.40                   | 12.20      | 7.20       | 9.80              | 4.60       | 5.20       |
| 11655   | Jan. 18.            | Distinct, milky. | Cons.     | 0.55   | 18.00                   | 9.40       | 8.60       | 5.60              | 2.80       | 2.80       |

*Chemical Examination of Sewage from Amherst—Concluded.*

[Parts per 100,000.]

| AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | OXYGEN CONSUMED. |           | IRON.       |           | Hardness. |
|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|-------------|-----------|-----------|
| Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. | Unfiltered.      | Filtered. | Unfiltered. | Filtered. |           |
|          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |             |           |           |
| 1.3200   | .2180       | .1000      | .1180      | 2.40      | .0100       | .0040     | 2.3068           | 1.6432    | .0740       | .0100     | 1.9       |
| 0.5360   | .0980       | .0380      | .0600      | 1.58      | .0100       | .0020     | 1.3272           | 0.8848    | .0400       | .0240     | 1.8       |

Odor, offensive. — The first sample was collected from the main sewer, before it enters the settling tank; the last, from the pipe which conveys the sewage from the settling tank to Fort River.

*Chemical Examination of Water from Fort River, Above and Below the Outlet of the Sewer from Amherst.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                    |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA. |             |            |                | Chlorine. | NITROGEN<br>AS |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|--------------------|--------|---------------------------------|----------------------|----------|-------------|------------|----------------|-----------|----------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.          | Color. | Total.                          | Loss on<br>Ignition. | Free.    | Albuminoid. |            |                |           | Nitrates.      | Nitrites. |                  |           |
|         |                     |             |                    |        |                                 |                      |          | Total.      | Dissolved. | Sus-<br>pended |           |                |           |                  |           |
| 11656   | 1894.<br>Jan. 18    | Slight.     | Slight,<br>earthy. | 0.28   | 3.75                            | 1.15                 | .0018    | .0028       | .0018      | .0010          | .19       | .0050          | .0001     | .2702            | 0.8       |
| 11657   | Jan. 18             | Slight.     | Slight.            | 0.28   | 4.05                            | 1.40                 | .0160    | .0060       | .0048      | .0012          | .26       | .0030          | .0002     | .3745            | 0.3       |

Odor, none. On heating, the odor of the second sample was distinctly disagreeable. — The first sample was collected from the river, about 100 feet above the sewer outlet; the last, from the river about 200 feet below the sewer outlet.

### SEWAGE DISPOSAL AT BROCKTON.

The sewage disposal system of the city of Brockton (population in 1895, 33,165) was first put in operation in November, 1894, and at the close of that year there had been a few connections made with the sewers. At the end of December, 1895, there were 221 connections, 110 of which were from dwelling-houses, 67 from factories and the remainder from business blocks, hotels and public buildings. The total length of sewers constructed to the end of the year 1895, including the main sewer, was 13.82 miles.

The principal industry in Brockton is the manufacture of shoes. The city is situated largely in the valley of the Salisbury Plain River, into which nearly all of the drainage naturally flows, and a large proportion of the population is in the immediate vicinity of the stream. The watershed of the river just below the city is only about 16 square miles, and the sewage of the city could not be discharged into it without creating a nuisance.

The system of sewerage adopted is what is known as the separate system, and as it was necessary in this case to pump all of the sewage, all surface water has been excluded from the system and great care has been taken to exclude ground water both from the street sewers and the house connections. Under-drains were constructed beneath all sewers, during the construction of which ground water was en-

countered, and special care was taken to make all joints tight. The under-drains discharge directly into the river or its tributaries at convenient points. The main or intercepting sewer is laid in low land bordering the river; it is egg-shaped in section, and at its lower end its size is 32 inches by 48 inches. At times of high water there is considerable leakage into it, and before any sewage was admitted to the sewers there was a large flow of ground water from the outlet of the intercepting sewer.

The sewage passes from the intercepting sewer at the pumping station into a covered masonry reservoir 110 feet long by 44 feet wide, having a capacity of about 500,000 gallons, sufficient to store the night flow of sewage and making it necessary to pump only during the day. The reservoir is ventilated by means of a 15-inch pipe connecting with the chimney of the pumping station. Between the reservoir and the pumps the sewage is screened by passing between iron plates placed so as to have an open space between them of three-fourths of an inch. From the pumping station the sewage is forced through a cast-iron force main 24 inches in diameter and nearly 17,000 feet in length to the filtration area.

The filtration area is situated in the south-westerly corner of the city, and comprises about 30 acres, being a part of a large area of flat, sandy land, locally known as the "muster field," the greater part of which is situated within the limits of the town of Easton. On this field 23 filter-beds have been prepared, having an average area, exclusive of embankments, of 1 acre. The loam was removed from all the beds. The subsoil was entirely removed from 12 of the beds, partially removed from 6, while in 5 of the beds the subsoil remains over the sand. The loam and subsoil which was removed was used in making the embankments between the beds. The filtering material varies from a fine gravel to a very fine sand, with the coarser material generally nearest the surface.

Under 10 of the beds a stratum of clay was found at a depth of from 7 to 8 feet, and in these beds 4 lines of 5-inch under-drains were constructed just above the clay, discharging through a 15-inch pipe into a small brook, a tributary of the Taunton River.

Although provision was made for the separation and removal of a portion of the solid matter from the sewage at the reservoir, there has as yet been no necessity for such separation, as the amount of sewage is so small that all of it can be disposed of on the beds.

An agitator has been placed in the bottom of the reservoir, through which sewage from the force main is introduced under pressure and by means of which all the solid matter which may have collected on the bottom may be thoroughly mixed with the liquid portion of the sewage and thus conveyed to the pumps. In the early operation of the plant it was the custom to start the agitator when the pumps were started and there was a large body of sewage in the reservoir, but by this method the sludge was distributed through the whole volume of sewage, and it was found that the beds soon became clogged. At the present time the agitator is put in operation just before the reservoir is emptied, and consequently the entire body of sludge, mixed with a small amount of sewage, is delivered at the field at once. Except when crops are being grown the sludge is discharged upon a separate bed, and when thoroughly dried the residue is raked up and burned.

The force main is so constructed that for about one-quarter of its length the pipe slopes towards the beds; but when the pumps are not running there are about 250,000 gallons remaining in the end of the pipe nearest the pumping station, which amount is stored there until pumping is resumed. When the daily amount of sewage pumped is less than 250,000 gallons, none of the sewage pumped into the force main one day reaches the filtration area until the next day, and consequently it has become quite stale when it is applied to the beds.

The method of operation has been to apply about 80,000 gallons of sewage to one bed, and then allow the filter to rest for a day before another dose is applied. During times of high flow in the sewers the size of the dose is much increased, but it is said that there has been no difficulty in disposing of all of the sewage, and 4 of the 23 beds have never been used.

During the winter of 1894-95 some of the beds were left with level surfaces; but it was found that in these beds the surface froze to such an extent that sewage could not be disposed of upon them, and the only beds which could be used during the cold weather were those which had been furrowed during the preceding fall. Accordingly all of the beds in use during the winter of 1895-96 were furrowed, and notwithstanding the low temperature of the sewage when received at the field, no difficulty was experienced from freezing.

The following table, taken from the report of the city engineer of Brockton for 1895, gives the average amount of sewage disposed of and the temperature of the sewage as it reaches the beds :—

| MONTH.            | Average Daily Flow at Field (Gallons). | Temperature Sewage at Field. | MONTH.             | Average Daily Flow at Field (Gallons). | Temperature Sewage at Field. |
|-------------------|----------------------------------------|------------------------------|--------------------|----------------------------------------|------------------------------|
| January, . . . .  | 215,000                                | 42.6                         | July, . . . .      | 195,000                                | 60.8                         |
| February, . . . . | 109,000                                | 40.6                         | August, . . . .    | 273,000                                | 64.0                         |
| March, . . . .    | 142,000                                | 39.5                         | September, . . . . | 275,000                                | 64.0                         |
| April, . . . .    | 250,000                                | 42.3                         | October, . . . .   | 488,000                                | 57.0                         |
| May, . . . .      | 338,000                                | 53.5                         | November, . . . .  | 474,000                                | 51.0                         |
| June, . . . .     | 228,000                                | 60.1                         |                    |                                        |                              |

*Chemical Examination of Sewage from Brockton.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |               |        | RESIDUE ON EVAPORATION. |            |            |                   |            |            |
|---------|---------------------|-------------|---------------|--------|-------------------------|------------|------------|-------------------|------------|------------|
|         |                     | Turbidity.  | Sediment.     | Color. | TOTAL RESIDUE.          |            |            | LOSS ON IGNITION. |            |            |
|         |                     |             |               |        | Total.                  | Dissolved. | Suspended. | Total.            | Dissolved. | Suspended. |
| 13814   | 1895.<br>Feb. 12.   | Thick.      | Heavy, black. | -      | 84.40                   | 40.20      | 44.20      | 38.00             | 12.40      | 25.60      |

*Chemical Examination of Sewage from Brockton—Concluded.*

[Parts per 100,000.]

| AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | OXYGEN CONSUMED. |           | IRON.       |           | Hardness. |
|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|-------------|-----------|-----------|
| Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. | Unfiltered.      | Filtered. | Unfiltered. | Filtered. |           |
|          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |             |           |           |
| 3.4560   | .9100       | .2440      | .6660      | 9.05      | .0000       | .0000     | 8.5600           | 3.1200    | .3200       | .0800     | 6.4       |

Odor, offensive. — The sample was collected as the sewage flowed out upon the filter beds.



*Chemical Examination of Effluent from the Under-drain at the Brockton Sewage Disposal Works.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |           |        | Residue on Evaporation. | AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |
|---------|---------------------|-------------|-----------|--------|-------------------------|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|
|         |                     | Turbidity.  | Sediment. | Color. |                         | Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |
| 13815   | 1895.<br>Feb. 12    | None.       | None.     | .01    | 4.00                    | .0248    | .0038       | .75       | .0450       | .0000     | .0240            | 0.6       | .0000 |

Odor, none. — The sample was collected from the under-drain near Pearl Street, and contains a large amount of ground water.

### SEWAGE DISPOSAL AT FRAMINGHAM.

The town of Framingham (population in 1895, 9,512) contains three villages, of which South Framingham is by far the most populous, and up to the present time is the only village sewered.

The sewerage system was put in operation near the end of the year 1889, and at the end of 1895 about 800 dwelling-houses and 50 business blocks, stores, factories, etc., were connected with the sewer. In addition to this, the sewage of the Women's Prison (population, about 350), located in the town of Sherborn just beyond the Framingham line, enters this system. The storm water is excluded from the sewers, and a continuous system of under-drains was laid beneath the principal sewers to collect and carry off the ground water. The amount of sewage flowing during a season of high rainfall, however, is fully three times the ordinary flow. The main under-drain, which formerly discharged into a brook feeding Lake Cochituate, now discharges into an open reservoir near the pumping station, from which it is pumped to some specially prepared filter-beds a short distance away from the station. The average daily amount of sewage pumped and purified during 1895 was about 400,000 gallons.

The sewage is collected in a pair of receiving reservoirs having a total capacity of 431,000 gallons, from which it is pumped through a cast-iron main, 12 inches in diameter and 9,740 feet in length, to the filtration area, located about  $2\frac{1}{2}$  miles north-east of the village of South Framingham. This area, a more detailed description of which, accompanied by a plan, may be found on page 560 of the annual

report of the Board for 1892, covers about 70 acres, much of which is quite level. The field is at an elevation of about 20 feet above Bannister Brook, which flows along its north-westerly border.

Three new filters, having an area of 4 acres, were constructed during the year 1894, making 13 beds with a total area of about 16 acres which have been specially prepared for sewage. About half of this area is under-drained to a limited extent.

During the summer nearly all of the filter-beds are planted with field corn (maize), and very satisfactory crops are obtained. A few other crops were raised to a small extent, some of which have been fairly satisfactory. The old beds upon which corn was grown were not disturbed after the last hoeing in the early part of July, and they have been found to give satisfactory results in cold weather, owing to the arrangement of the surfaces in hills and furrows, thus enabling a covering of snow and ice to rest on the hills, and reducing the exposure of the material in the furrows to frost.

The quality of the sewage and effluent from several different places may be seen by the tables of analyses on the following pages. The sewage is ordinary town sewage, discolored and somewhat modified at times by a considerable amount of spent dyes discharged into the sewers from the straw-goods factories in the town.

For the results of chemical and bacterial analyses, showing the variations at different hours of the day in composition of the summer sewage, and measurements of its quantity, reference is made to page 469 of the annual report for 1894 and to page 456 of this volume.

## Chemical Examination of

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.               |                          |         | RESIDUE ON EVAPORATION. |            |            |                   |            |            |
|---------|---------------------|---------------------------|--------------------------|---------|-------------------------|------------|------------|-------------------|------------|------------|
|         |                     | Turbidity.                | Sediment.                | Color.* | TOTAL RESIDUE.          |            |            | LOSS ON IGNITION. |            |            |
|         |                     |                           |                          |         | Total.                  | Dissolved. | Suspended. | Total.            | Dissolved. | Suspended. |
| 1894.   |                     |                           |                          |         |                         |            |            |                   |            |            |
| 1       | 11593 Jan. 3        | Decided, milky.           | Cons., dark.             | 0.50    | 35.40                   | 30.00      | 5.40       | 15.80             | 10.80      | 5.00       |
| 2       | 11658 Jan. 18       | Thick.                    | Heavy, dark.             | -       | 39.00                   | 31.20      | 7.80       | 16.80             | 11.20      | 5.60       |
| 3       | 11771 Feb. 12       | Thick.                    | Cons., dark.             | -       | 36.00                   | 29.40      | 6.60       | 13.40             | 7.60       | 5.80       |
| 4       | 11907 Mar. 15       | Decided.                  | Heavy, gray.             | 0.90    | 30.80                   | 24.00      | 6.80       | 9.00              | 4.80       | 4.20       |
| 5       | 11949 Mar. 27       | Thick.                    | Cons., dark.             | 0.80    | 57.20                   | 30.00      | 27.20      | 30.00             | 5.00       | 25.00      |
| 6       | 12022 April 10      | Decided, milky.           | Heavy, gray.             | 0.50    | 103.60                  | 32.40      | 71.20      | 76.60             | 12.80      | 63.80      |
| 7       | 12107 April 26      | Decided.                  | Heavy, gray.             | 0.90    | 31.00                   | 26.60      | 5.00       | 11.00             | 7.00       | 4.00       |
| 8       | 12193 May 10        | Decided, milky.           | Cons., dark.             | -       | 31.20                   | 27.60      | 3.60       | 11.20             | 8.60       | 2.60       |
| 9       | 12347 June 11       | Thick.                    | Heavy, dark.             | -       | 115.20                  | 33.00      | 82.20      | 82.40             | 11.60      | 70.80      |
| 10      | 12510 July 10       | Thick.                    | V. heavy, dark.          | -       | 139.00                  | 62.60      | 76.40      | 87.80             | 22.00      | 65.80      |
| 11      | 12709 Aug. 10       | Thick, dark.              | Heavy, black.            | -       | 58.00                   | 31.80      | 26.20      | 31.20             | 9.60       | 21.60      |
| 12      | 12952 Sept. 12      | Thick.                    | V. heavy, dark.          | 1.30    | 51.60                   | 39.20      | 12.40      | 26.00             | 15.20      | 10.80      |
| 13      | 13087 Oct. 5        | Thick.                    | Cons., dark.             | 1.00    | 47.40                   | 41.80      | 5.60       | 19.40             | 14.00      | 5.40       |
| 14      | 13361 Nov. 21       | Thick.                    | Cons., white.            | 0.40    | 33.90                   | 29.10      | 4.80       | 12.50             | 8.30       | 4.20       |
| 15      | 13536 Dec. 21       | Decided.                  | Cons., gray.             | 1.20    | 31.30                   | 23.70      | 7.60       | 10.20             | 7.30       | 2.90       |
| 16      | Av. ....            | .....                     | .....                    | -       | 57.70                   | 38.78      | 23.92      | 31.17             | 10.83      | 20.33      |
| 1895.   |                     |                           |                          |         |                         |            |            |                   |            |            |
| 17      | 13642 Jan. 12       | Decided.                  | Heavy, black.            | 1.40    | 35.30                   | 28.50      | 6.50       | 14.20             | 8.50       | 5.40       |
| 18      | 13721 Jan. 23       | Decided.                  | Cons., gray.             | 0.40    | 73.80                   | 23.70      | 50.10      | 55.20             | 6.40       | 48.40      |
| 19      | 13787 Feb. 9        | Decided.                  | Cons., gray.             | 0.90    | 32.50                   | 22.10      | 10.40      | 12.00             | 4.00       | 8.00       |
| 20      | 14071 April 1       | Decided.                  | Heavy, dark.             | -       | 37.80                   | 28.10      | 9.70       | 16.90             | 8.90       | 8.00       |
| 21      | 14129 April 10      | Decided.                  | Heavy, gray.             | 0.40    | 115.40                  | 32.70      | 82.70      | 88.20             | 11.70      | 76.50      |
| 22      | 14318 May 17        | Decided.                  | Heavy, dark.             | -       | 59.60                   | 29.40      | 30.20      | 33.00             | 9.40       | 23.60      |
| 23      | 14462 June 11       | Decided.                  | Heavy, gray and dark.    | -       | 50.80                   | 39.90      | 10.90      | 21.00             | 13.60      | 8.20       |
| 24      | 14671 July 22       | Decided.                  | Heavy, gray.             | -       | 38.40                   | 34.60      | 3.80       | 15.20             | 10.60      | 4.60       |
| 25      | 14803 Aug. 12       | Thick.                    | Heavy, dark.             | 0.40    | 39.20                   | 31.60      | 7.60       | 21.00             | 13.40      | 7.60       |
| 26      | 15198 Sept. 17      | Thick.                    | Cons., dark.             | 0.60    | 42.10                   | 34.50      | 7.60       | 17.40             | 12.20      | 5.20       |
| 27      | 15379 Oct. 16       | Thick.                    | Heavy, black.            | -       | 307.40                  | 27.60      | 339.80     | 289.40            | 8.20       | 281.20     |
| 28      | 15512 Nov. 11       | Decided, milky and flocc. | Cons., coarse and flocc. | 0.20    | 25.40                   | 22.40      | 3.00       | 9.00              | 6.80       | 2.20       |
| 29      | 15715 Dec. 10       | Decided, milky.           | Cons.                    | 0.60    | 57.80                   | 28.20      | 29.60      | 36.00             | 8.80       | 27.20      |
| 30      | 15807 Dec. 25       | Decided, milky.           | Cons., dark.             | 0.35    | 38.80                   | 22.60      | 16.20      | 18.80             | 5.00       | 13.80      |
| 31      | Av. ....            | .....                     | .....                    | -       | 75.95                   | 29.55      | 46.41      | 48.92             | 9.44       | 39.48      |

\* The color of many samples was affected by the presence of spent dye liquors in the sewage, and in many cases could not be determined satisfactorily.

*Sewage from Framingham.*

[Parts per 100,000.]

| AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | OXYGEN CONSUMED. |           | IRON.       |           | Hardness. |    |
|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|-------------|-----------|-----------|----|
| Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. | Unfiltered.      | Filtered. | Unfiltered. | Filtered. |           |    |
|          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |             |           |           |    |
| 1.9200   | 0.3180      | .1900      | .1280      | 4.00      | .0000       | .0000     | 3.8610           | 3.0810    | .0560       | .0560     | 5.3       | 1  |
| 1.9920   | 0.3560      | .2280      | .1280      | 5.02      | .0000       | .0000     | 5.7196           | 4.2976    | .1360       | .0880     | 5.3       | 2  |
| 2.1760   | 0.3900      | .3020      | .0880      | 3.79      | .0000       | .0000     | 3.5200           | 2.4800    | .1080       | .0700     | 5.4       | 3  |
| 1.3440   | 0.2880      | .1520      | .1360      | 3.97      | .0050       | .0400     | 3.1040           | 2.0800    | .1400       | .0760     | 7.3       | 4  |
| 1.6000   | 0.4660      | .2820      | .1840      | 4.40      | .0050       | .0000     | 5.3900           | 3.8885    | .1000       | .0900     | 6.6       | 5  |
| 1.7600   | 0.7500      | .3740      | .3760      | 4.34      | .0050       | .0000     | 6.1857           | 2.6465    | .2800       | .0640     | 7.3       | 6  |
| 1.0560   | 0.2620      | .1480      | .1140      | 4.41      | .0000       | .0600     | 3.3259           | 2.3937    | .1000       | .0640     | 6.4       | 7  |
| 1.2160   | 0.2880      | .2020      | .0860      | 3.63      | .0000       | .0000     | 2.8700           | 2.0500    | .0920       | .0720     | 6.1       | 8  |
| 2.0160   | 0.6160      | .2080      | .4080      | 5.53      | .0000       | .0000     | 3.6652           | 2.3100    | -           | -         | 7.4       | 9  |
| 4.4000   | 1.0440      | .3520      | .6920      | 10.00     | .0000       | .0000     | -                | 4.0117    | -           | -         | 11.0      | 10 |
| 2.4000   | 0.9360      | .2080      | .7280      | 7.20      | .0000       | .0000     | 5.3130           | 1.5400    | -           | -         | 5.4       | 11 |
| 4.5000   | 0.4800      | .2440      | .2360      | 7.25      | .0000       | .0000     | 3.7268           | 2.2176    | .0900       | .0500     | 5.1       | 12 |
| 3.8400   | 0.3960      | .3060      | .0800      | 9.00      | .0000       | .0000     | 5.7670           | 2.8835    | .0920       | .0600     | 5.0       | 13 |
| 1.7920   | 0.3720      | .2240      | .1480      | 5.60      | .0000       | .0000     | 2.9250           | 1.6380    | .0920       | .0540     | 5.7       | 14 |
| 2.0800   | 0.4300      | .2760      | .1540      | 5.22      | .0000       | .0000     | 3.0800           | 2.5025    | .0600       | .0300     | 5.9       | 15 |
| 2.4380   | 0.5135      | .2508      | .2627      | 5.86      | .0006       | .0042     | 4.0690           | 2.5689    | .1044       | .0617     | 6.4       | 16 |
| 1.9200   | 0.4320      | .2860      | 0.1360     | 4.83      | .0000       | .0000     | 3.9500           | 2.6070    | .0650       | .0380     | 8.1       | 17 |
| 1.6640   | 0.3560      | .1980      | 0.1580     | 4.38      | .0000       | .0010     | 2.7256           | 1.6195    | .1120       | .0400     | 6.3       | 18 |
| 1.6320   | 0.3100      | .2440      | 0.0660     | 4.40      | .0000       | .0090     | 4.1600           | 2.4960    | .1300       | .0570     | 5.7       | 19 |
| 1.9200   | 0.5200      | .2780      | 0.2420     | 4.90      | .0000       | .0000     | 3.6190           | 2.3100    | .0650       | .0300     | 8.1       | 20 |
| 1.8240   | 0.6760      | .3000      | 0.3760     | 4.40      | .0000       | .0000     | 6.2755           | 2.8105    | .1400       | .0350     | 6.4       | 21 |
| 2.6240   | 0.6780      | .2980      | 0.3800     | 6.00      | .0000       | .0000     | 7.3075           | 3.0415    | .1760       | .0520     | 7.9       | 22 |
| 11.0080  | 0.4720      | .1960      | 0.2760     | 8.60      | .0000       | .0000     | 4.7424           | 2.6520    | .1250       | .0600     | 7.0       | 23 |
| 2.5600   | 0.3420      | .2160      | 0.1260     | 7.10      | .0000       | .0000     | 2.3625           | 1.9875    | .0900       | .0800     | 6.9       | 24 |
| 1.9840   | 0.2800      | .1540      | 0.1260     | 6.60      | .0000       | .0000     | 2.9640           | 1.6770    | .1160       | .0600     | 7.4       | 25 |
| 3.9680   | 0.4240      | .2080      | 0.2160     | 7.45      | .0000       | .0000     | 4.3290           | 2.3556    | -           | -         | 5.6       | 26 |
| 0.8000   | 3.6300      | .1500      | 3.4800     | 3.95      | .0000       | .0000     | 25.3890          | 2.4180    | .7300       | .0940     | 8.0       | 27 |
| 0.7680   | 0.1900      | .0840      | 0.1060     | 3.60      | .0050       | .0830     | 1.6770           | 0.8190    | .0680       | .0560     | 7.0       | 28 |
| 1.8240   | 0.5080      | .2040      | 0.3040     | 4.15      | .0400       | .0400     | 6.1230           | 2.7690    | .0600       | .0400     | 7.7       | 29 |
| 1.6320   | 0.4260      | .2540      | 0.1720     | 4.16      | .0000       | .0000     | 3.3110           | 1.5246    | .1360       | .0460     | 6.6       | 30 |
| 2.7173   | 0.6986      | .2166      | 0.4820     | 5.48      | .0021       | .0094     | 5.9067           | 2.2356    | .1522       | .0551     | 7.0       | 31 |

Odor, offensive. — The sewage was collected as it flowed out upon the filter-beds.

*Chemical Examination of Effluent from the East*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.   |                 |        | ODOR.                              |                                   | Residue on Evaporation. |
|---------|---------------------|---------------|-----------------|--------|------------------------------------|-----------------------------------|-------------------------|
|         |                     | Turbidity.    | Sediment.       | Color. | Cold.                              | Hot.                              |                         |
| 1894.   |                     |               |                 |        |                                    |                                   |                         |
| 1       | 11595 Jan. 3        | Slight, acum. | Slight.         | .00    | None.                              | Very faint or none.               | 25.3                    |
| 2       | 11660 Jan. 18       | None.         | None.           | .00    | Very faint or none.                | Faintly musty.                    | 22.5                    |
| 3       | 11773 Feb. 12       | Very slight.  | Very slight.    | .02    | Distinctly musty.                  | Faintly musty.                    | 20.8                    |
| 4       | 11909 Mar. 15       | Very slight.  | Very slight.    | .01    | Faintly musty.                     | Decidedly musty.                  | 18.4                    |
| 5       | 11951 Mar. 27       | None.         | Very slight.    | .01    | Faintly musty.                     | Decidedly musty.                  | 18.5                    |
| 6       | 12024 April 10      | None.         | Cons.           | .00    | Distinctly musty.                  | Decidedly musty.                  | 21.4                    |
| 7       | 12109 April 26      | None.         | Very slight.    | .02    | Very faint or none.                | Very faintly musty.               | 21.7                    |
| 8       | 12195 May 10        | Distinct.     | Slight.         | .15    | Decidedly musty.                   | Decidedly musty.                  | 19.7                    |
| 9       | 12349 June 11       | Very slight.  | Very slight.    | .04    | Distinctly musty.                  | Decidedly musty and disagreeable. | 25.5                    |
| 10      | 12512 July 10       | None.         | Slight, rusty.  | .02    | Faintly musty.                     | Faintly musty.                    | 29.4                    |
| 11      | 12711 Aug. 10       | None.         | Very slight.    | .02    | None.                              | None.                             | 37.6                    |
| 12      | 12953 Sept. 12      | None.         | Slight, earthy. | .02    | Faintly musty.                     | Very faint or none.               | 28.0                    |
| 13      | 13089 Oct. 5        | Slight.       | Slight.         | .03    | None.                              | Faintly musty.                    | 30.0                    |
| 14      | 13362 Nov. 21       | None.         | Very slight.    | .02    | Very faintly musty.                | Decidedly musty.                  | 28.7                    |
| 15      | 13538 Dec. 21       | Very slight.  | Slight.         | .01    | Distinctly musty.                  | Distinctly musty.                 | 25.0                    |
| 16      | Av. ....            | .....         | .....           | .03    | .....                              | .....                             | 25.54                   |
| 1895.   |                     |               |                 |        |                                    |                                   |                         |
| 17      | 13644 Jan. 12       | None.         | None.           | .04    | Faintly earthy.                    | Distinctly musty.                 | 26.0                    |
| 18      | 13723 Jan. 23       | Very slight.  | Cons., sand.    | .03    | Distinctly musty and disagreeable. | Decidedly musty.                  | 25.5                    |
| 19      | 13788 Feb. 9        | Very slight.  | None.           | .01    | Decidedly disagreeable and musty.  | Decidedly musty.                  | 23.6                    |
| 20      | 14072 April 1       | Slight.       | Cons.           | .12    | Offensive.                         | Offensive.                        | 20.6                    |
| 21      | 14130 April 10      | Very slight.  | Very slight.    | .03    | Offensive.                         | Offensive.                        | 20.9                    |
| 22      | 14320 May 17        | Very slight.  | Very slight.    | .02    | Faintly musty and disagreeable.    | Decidedly musty and disagreeable. | 26.9                    |
| 23      | 14464 June 11       | None.         | Very slight.    | .02    | Decidedly musty.                   | Decidedly musty and disagreeable. | 41.2                    |
| 24      | 14673 July 22       | None.         | Slight, sand.   | .02    | Distinctly musty and disagreeable. | Decidedly musty and disagreeable. | 41.5                    |
| 25      | 14805 Aug. 12       | None.         | None.           | .00    | Very faintly musty.                | Distinctly musty.                 | 40.6                    |
| 26      | 15200 Sept. 17      | None.         | None.           | .02    | None.                              | Very faintly musty.               | 34.2                    |
| 27      | 15381 Oct. 16       | Very slight.  | Very slight.    | .10    | None.                              | Very faint or none.               | 28.6                    |
| 28      | 15514 Nov. 11       | None.         | None.           | .05    | None.                              | Distinctly musty.                 | 23.4                    |
| 29      | 15717 Dec. 10       | Very slight.  | Slight.         | .02    | None.                              | Distinctly musty.                 | 22.6                    |
| 30      | 15509 Dec. 26       | None.         | None.           | .00    | None.                              | None.                             | 22.7                    |
| 31      | Av. ....            | .....         | .....           | .04    | .....                              | .....                             | 29.15                   |

The samples were collected from

*Under-drain of the Framingham Filter-beds.*

[Parts per 100,000.]

| AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |    |
|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|----|
| Free.    | Albaminoid. |           | Nitrates.   | Nitrites. |                  |           |       |    |
| .0480    | .0140       | 3.57      | 1.2500      | .0045     | .0975            | 5.4       | .0050 | 1  |
| .0920    | .0000       | 3.84      | 0.7500      | .0020     | .1059            | 5.4       | .0000 | 2  |
| .0820    | .0064       | 3.42      | 0.7000      | .0040     | .1138            | 5.1       | .0040 | 3  |
| .0400    | .0072       | 2.75      | 0.7000      | .0030     | .1120            | 3.9       | .0160 | 4  |
| .0320    | .0060       | 2.98      | 1.0000      | .0070     | .1078            | 4.9       | .0050 | 5  |
| .0200    | .0070       | 3.19      | 0.5000      | .0030     | .1135            | 4.6       | .0000 | 6  |
| .0480    | .0080       | 3.62      | 1.1500      | .0020     | .1161            | 5.0       | .0020 | 7  |
| .0350    | .0080       | 3.42      | 0.5000      | .0040     | .2230            | 5.1       | .0500 | 8  |
| .0840    | .0180       | 3.77      | 0.9300      | .0080     | .1317            | 5.7       | -     | 9  |
| .0140    | .0062       | 4.79      | 1.2200      | .0010     | .1817            | 5.3       | .0000 | 10 |
| .0190    | .0090       | 5.20      | 2.5000      | .0020     | .0693            | 7.7       | .0050 | 11 |
| .0480    | .0040       | 4.85      | 1.3250      | .0030     | .1001            | 4.7       | .0100 | 12 |
| .0640    | .0080       | 5.81      | 1.8750      | .0030     | .1066            | 5.7       | .0130 | 13 |
| .0086    | .0064       | 6.00      | 1.0000      | .0005     | .1108            | 6.6       | .0020 | 14 |
| .1160    | .0210       | 5.16      | 0.1800      | .0020     | .1155            | 4.9       | .0150 | 15 |
| .0467    | .0089       | 4.37      | 1.0754      | .0032     | .1234            | 5.5       | .0103 | 16 |
| .0760    | .0140       | 5.22      | 0.8750      | .0014     | .1422            | 6.3       | .0020 | 17 |
| .2400    | .0200       | 5.00      | 0.7500      | .0180     | .2172            | 5.3       | .0020 | 18 |
| .2800    | .0180       | 4.95      | 0.4750      | .0080     | .2544            | 5.6       | .0010 | 19 |
| .5920    | .0100       | 3.90      | 0.2900      | .0180     | .2502            | 5.1       | .0700 | 20 |
| .4000    | .0110       | 3.95      | 0.4750      | .0030     | .1925            | 4.7       | .0280 | 21 |
| .3920    | .0060       | 3.70      | 1.2500      | .0020     | .1580            | 6.6       | .0010 | 22 |
| .4800    | .0050       | 4.00      | 2.2500      | .0050     | .1599            | 9.1       | .0020 | 23 |
| .3200    | .0030       | 5.15      | 2.5000      | .0040     | .1312            | 10.1      | .0030 | 24 |
| .2000    | .0080       | 5.60      | 1.7000      | .0020     | .1326            | 9.6       | .0000 | 25 |
| .1080    | .0000       | 6.00      | 2.0000      | .0050     | .1092            | 7.1       | .0010 | 26 |
| .0720    | .0130       | 6.25      | 0.9500      | .0020     | .1521            | 7.0       | .0430 | 27 |
| .0440    | .0058       | 4.80      | 1.2400      | .0130     | .0920            | 4.7       | .0080 | 28 |
| .0400    | .0070       | 3.88      | 0.6800      | .0010     | .1264            | 5.6       | .0100 | 29 |
| .0202    | .0042       | 4.12      | 0.8000      | .0013     | .0539            | 5.4       | .0020 | 30 |
| .2563    | .0085       | 4.78      | 1.2235      | .0057     | .1585            | 6.7       | .0137 | 31 |

the under-drain at its outlet.

*Chemical Examination of Effluent from the West*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.           |                      |        | ODOR.                              |                                    | Residue on Evaporation. |
|---------|---------------------|-----------------------|----------------------|--------|------------------------------------|------------------------------------|-------------------------|
|         |                     | Turbidity.            | Sediment.            | Color. | Cold.                              | Hot.                               |                         |
| 1894.   |                     |                       |                      |        |                                    |                                    |                         |
| 1       | 11594 Jan. 3        | None.                 | Slight.              | .00    | Very faintly musty.                | Distinctly musty.                  | 25.90                   |
| 2       | 11659 Jan. 18       | Very slight.          | Very slight.         | .00    | Very faint or none.                | Distinctly musty and mouldy.       | 23.50                   |
| 3       | 11772 Feb. 13       | Slight.               | Slight.              | .02    | Faintly musty.                     | Faintly musty.                     | 22.30                   |
| 4       | 11908 Mar. 15       | None.                 | Very slight.         | .01    | Decidedly musty.                   | Decidedly musty.                   | 19.40                   |
| 5       | 11950 Mar. 27       | None.                 | Very slight.         | .01    | Very faintly musty.                | Faintly musty.                     | 20.40                   |
| 6       | 12023 April 10      | None.                 | Cons.                | .02    | Distinctly musty and disagreeable. | Decidedly musty and disagreeable.  | 16.00                   |
| 7       | 12108 April 26      | Very slight.          | Slight, white.       | .02    | Very faintly musty.                | Very faintly musty.                | 21.30                   |
| 8       | 12194 May 10        | Very slight.          | Slight.              | .00    | Decidedly musty.                   | Faintly musty.                     | 22.30                   |
| 9       | 12348 June 11       | Slight.               | Slight.              | .02    | Faintly mouldy.                    | Decidedly mouldy.                  | 27.30                   |
| 10      | 12511 July 10       | None.                 | Very slight.         | .02    | Faintly musty.                     | Distinctly musty.                  | 33.50                   |
| 11      | 12710 Aug. 10       | None.                 | Very slight.         | .04    | None.                              | Faintly musty.                     | 33.10                   |
| 12      | 12954 Sept. 12      | None.                 | Slight, green.       | .07    | None.                              | None.                              | 33.30                   |
| 13      | 13088 Oct. 5        | Slight.               | Cons., brown.        | .02    | Very faint or none.                | Distinctly musty.                  | 35.50                   |
| 14      | 13363 Nov. 21       | Very slight.          | Very slight.         | .02    | None.                              | Very faintly musty.                | 25.00                   |
| 15      | 13537 Dec. 21       | None.                 | Cons.                | .01    | Decidedly musty and disagreeable.  | Distinctly musty.                  | 27.00                   |
| 16      | Av. ....            | .....                 | .....                | .02    | .....                              | .....                              | 27.00                   |
| 1895.   |                     |                       |                      |        |                                    |                                    |                         |
| 17      | 13643 Jan. 12       | None.                 | Very slight.         | .03    | Very faint or none.                | Faintly musty.                     | 20.30                   |
| 18      | 13722 Jan. 23       | None.                 | None.                | .02    | Very faintly musty.                | Distinctly musty.                  | 20.70                   |
| 19      | 13789 Feb. 9        | Very slight.          | None.                | .03    | Distinctly disagreeable and musty. | Distinctly musty.                  | 21.60                   |
| 20      | 14073 April 1       | Distinct.             | Slight.              | .15    | Offensive.                         | Offensive.                         | 18.80                   |
| 21      | 14131 April 10      | Very slight.          | Slight.              | .10    | Offensive.                         | Offensive.                         | 17.70                   |
| 22      | 14319 May 17        | Slight.               | Slight.              | .05    | Decidedly musty and disagreeable.  | Offensive.                         | 22.50                   |
| 23      | 14463 June 11       | Very slight.          | Slight.              | .07    | Decidedly musty.                   | Decidedly musty and disagreeable.  | 27.30                   |
| 24      | 14672 July 22       | None.                 | Very slight.         | .04    | Distinctly musty and disagreeable. | Decidedly musty and disagreeable.  | 32.50                   |
| 25      | 14804 Aug. 12       | Slight.               | Slight.              | .40    | Faintly musty.                     | Distinctly musty and disagreeable. | 33.70                   |
| 26      | 15199 Sept. 17      | Slight.               | Slight.              | .02    | None.                              | Distinctly musty.                  | 32.90                   |
| 27      | 15380 Oct. 16       | Very slight.          | Very slight.         | .10    | Distinctly unpleasant.             | Distinctly unpleasant.             | 26.40                   |
| 28      | 15513 Nov. 11       | Distinct, white floc. | Slight, yellow floc. | .07    | None.                              | Faintly musty.                     | 26.00                   |
| 29      | 15718 Dec. 10       | None.                 | Very slight.         | .04    | None.                              | Very faintly musty.                | 21.60                   |
| 30      | 15808 Dec. 26       | None.                 | Very slight.         | .01    | None.                              | Faintly musty.                     | 23.10                   |
| 31      | Av. ....            | .....                 | .....                | .09    | .....                              | .....                              | 25.24                   |

The samples were collected from

*Under-drain at the Framingham Filter-beds.*

[Parts per 100,000.]

| AMMONIA. |             | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |    |
|----------|-------------|-----------|-------------|-----------|------------------|-----------|-------|----|
| Free.    | Albuminoid. |           | Nitrates.   | Nitrites. |                  |           |       |    |
| .0400    | .0020       | 3.76      | 0.9750      | .0015     | .1365            | 8.0       | .0040 | 1  |
| .0720    | .0000       | 3.75      | 0.9000      | .0020     | .1335            | 5.4       | .0000 | 2  |
| .5440    | .0076       | 3.74      | 0.7000      | .0020     | .1376            | 6.0       | .0130 | 3  |
| .0560    | .0040       | 3.00      | 0.9000      | .0030     | .1040            | 4.7       | .0050 | 4  |
| .0600    | .0050       | 3.17      | 1.1000      | .0060     | .1540            | 5.1       | .0100 | 5  |
| .0384    | .0076       | 2.57      | 0.5250      | .0020     | .1659            | 4.2       | .0050 | 6  |
| .0344    | .0092       | 3.55      | 1.1000      | .0030     | .0908            | 5.0       | .0100 | 7  |
| .0530    | .0060       | 3.55      | 0.9500      | .0010     | .1189            | 5.6       | .0000 | 8  |
| .0336    | .0056       | 3.58      | 1.2600      | .0010     | .0924            | 6.0       | -     | 9  |
| .0360    | .0060       | 4.82      | 1.3750      | .0040     | .1270            | 8.2       | .0140 | 10 |
| .0202    | .0078       | 4.60      | 1.6660      | .0017     | .0862            | 6.4       | .0030 | 11 |
| .0182    | .0064       | 5.19      | 1.7500      | .0010     | .0770            | 6.9       | .0030 | 12 |
| .0112    | .0084       | 5.00      | 1.7000      | .0004     | .1264            | 5.7       | .0200 | 13 |
| .0068    | .0064       | 5.00      | 1.2000      | .0002     | .0858            | 6.4       | .0010 | 14 |
| .1040    | .0190       | 4.84      | 1.0000      | .0030     | .1424            | 6.3       | .0060 | 15 |
| .0812    | .0070       | 4.17      | 1.1960      | .0019     | .1155            | 6.1       | .0070 | 16 |
| .0192    | .0072       | 3.58      | 0.8250      | .0012     | .1619            | 4.9       | .0060 | 17 |
| .0116    | .0060       | 3.77      | 0.9500      | .0005     | .0711            | 4.4       | .0020 | 18 |
| .0784    | .0112       | 4.40      | 0.7000      | .0130     | .1744            | 5.1       | .0040 | 19 |
| .5200    | .0100       | 4.00      | 0.2000      | .0050     | .2556            | 4.3       | .1000 | 20 |
| .3620    | .0150       | 3.65      | 0.3000      | .0030     | .2541            | 4.4       | .1480 | 21 |
| .2480    | .0070       | 4.40      | 0.6800      | .0040     | .1501            | 5.3       | .0240 | 22 |
| .3520    | .0070       | 3.95      | 0.8000      | .0040     | .1677            | 6.3       | .0220 | 23 |
| .3120    | .0050       | 5.20      | 0.8750      | .0100     | .1575            | 8.7       | .0140 | 24 |
| .2400    | .0100       | 5.10      | 1.0500      | .0040     | .5070            | 7.9       | .1600 | 25 |
| .1520    | .0040       | 5.60      | 1.5000      | .0060     | .1186            | 7.0       | .0080 | 26 |
| .1120    | .0150       | 5.15      | 0.9500      | .0020     | .1677            | 6.0       | .0600 | 27 |
| .1280    | .0040       | 4.80      | 2.0000      | .0040     | .1170            | 6.3       | .0880 | 28 |
| .0636    | .0074       | 3.79      | 0.9500      | .0020     | .0936            | 5.3       | .0220 | 29 |
| .0640    | .0040       | 3.56      | 1.0000      | .0020     | .0693            | 5.4       | .0140 | 30 |
| .2145    | .0084       | 4.47      | 0.9098      | .0048     | .1890            | 5.9       | .0542 | 31 |

the under-drain at its outlet.



*Chemical Examination of Water from a Spring near Bannister*

[Parts per 100,000.]

|    | Number.  | Date of Collection. | APPEARANCE. |            |        | ODOR.                  |                          | Residue on Evaporation. |
|----|----------|---------------------|-------------|------------|--------|------------------------|--------------------------|-------------------------|
|    |          |                     | Turbidity.  | Sediment.  | Color. | Cold.                  | Hot.                     |                         |
|    |          | <b>1894.</b>        |             |            |        |                        |                          |                         |
| 1  | 11596    | Jan. 3              | None.       | None.      | .00    | None.                  | None.                    | 16.00                   |
| 2  | 11661    | Jan. 18             | None.       | None.      | .00    | None.                  | None.                    | 15.50                   |
| 3  | 11774    | Feb. 12             | None.       | None.      | .00    | None.                  | None.                    | 16.40                   |
| 4  | 11910    | Mar. 15             | None.       | None.      | .00    | None.                  | None.                    | 17.00                   |
| 5  | 11952    | Mar. 27             | None.       | None.      | .00    | None.                  | None.                    | 15.90                   |
| 6  | 12025    | April 10            | None.       | Slight.    | .00    | V. faint or none.      | None.                    | 16.90                   |
| 7  | 12110    | April 26            | None.       | None.      | .00    | None.                  | None.                    | 17.20                   |
| 8  | 12196    | May 10              | None.       | None.      | .00    | None.                  | None.                    | 19.20                   |
| 9  | 12350    | June 11             | None.       | None.      | .00    | None.                  | None.                    | 18.80                   |
| 10 | 12513    | July 10             | None.       | None.      | .00    | None.                  | None.                    | 19.00                   |
| 11 | 12712    | Aug. 10             | None.       | V. slight. | .01    | Distinctly unpleasant. | Distinctly disagreeable. | 20.80                   |
| 12 | 12955    | Sept. 12            | None.       | None.      | .02    | None.                  | None.                    | 20.50                   |
| 13 | 13090    | Oct. 5              | None.       | None.      | .02    | None.                  | None.                    | 19.20                   |
| 14 | 13364    | Nov. 21             | None.       | None.      | .00    | None.                  | None.                    | 18.50                   |
| 15 | 13539    | Dec. 21             | None.       | None.      | .01    | None.                  | None.                    | 18.20                   |
| 16 | Av. .... | .....               | .....       | .....      | .01    | .....                  | .....                    | 18.37                   |
|    |          | <b>1895.</b>        |             |            |        |                        |                          |                         |
| 17 | 13645    | Jan. 12             | None.       | None.      | .00    | None.                  | None.                    | 18.20                   |
| 18 | 13724    | Jan. 23             | None.       | None.      | .00    | None.                  | None.                    | 18.50                   |
| 19 | 13790    | Feb. 9              | None.       | None.      | .02    | None.                  | None.                    | 18.60                   |
| 20 | 14074    | April 1             | None.       | None.      | .00    | None.                  | None.                    | 18.50                   |
| 21 | 14132    | April 10            | None.       | None.      | .00    | None.                  | None.                    | 18.40                   |
| 22 | 14321    | May 17              | None.       | V. slight. | .00    | None.                  | None.                    | 15.00                   |
| 23 | 14465    | June 11             | None.       | None.      | .00    | None.                  | None.                    | 17.70                   |
| 24 | 14674    | July 22             | None.       | None.      | .00    | None.                  | None.                    | 19.70                   |
| 25 | 14806    | Aug. 12             | None.       | None.      | .00    | None.                  | None.                    | 22.80                   |
| 26 | 15201    | Sept. 17            | None.       | None.      | .00    | None.                  | None.                    | 20.80                   |
| 27 | 15382    | Oct. 16             | None.       | V. slight. | .00    | None.                  | None.                    | 19.10                   |
| 28 | 15515    | Nov. 12             | None.       | None.      | .00    | None.                  | None.                    | 18.50                   |
| 29 | 15716    | Dec. 10             | V. slight.  | V. slight. | .00    | None.                  | None.                    | 14.70                   |
| 30 | 15810    | Dec. 26             | None.       | None.      | .00    | None.                  | None.                    | 17.60                   |
| 31 | Av. .... | .....               | .....       | .....      | .00    | .....                  | .....                    | 18.71                   |

*Brook which receives Effluent from the Framingham Filter-beds.*

[Parts per 100,000.]

| AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |    |
|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|----|
| Free.    | Albu-<br>minoid. |           | Nitrates.   | Nitrates. |                  |           |       |    |
| .0000    | .0006            | 2.97      | 0.5250      | .0000     | .0195            | 4.3       | .0000 | 1  |
| .0000    | .0000            | 2.92      | 0.7000      | .0000     | .0000            | 4.2       | .0000 | 2  |
| .0000    | .0028            | 3.18      | 0.6500      | .0000     | .0240            | 4.6       | .0000 | 3  |
| .0004    | .0082            | 2.81      | 0.8000      | .0000     | .0184            | 4.2       | .0050 | 4  |
| .0000    | .0014            | 2.80      | 0.7000      | .0000     | .0423            | 3.8       | .0000 | 5  |
| .0000    | .0016            | 3.02      | 0.7500      | .0001     | .0434            | 4.3       | .0050 | 6  |
| .0012    | .0038            | 3.23      | 0.9000      | .0000     | .0261            | 4.0       | .0000 | 7  |
| .0000    | .0044            | 3.18      | 0.9000      | .0000     | .0558            | 4.3       | .0000 | 8  |
| .0000    | .0024            | 3.18      | 0.7500      | .0000     | .0298            | 3.8       | -     | 9  |
| .0004    | .0010            | 3.19      | 0.4000      | .0000     | .0431            | 4.6       | .0050 | 10 |
| .0024    | .0056            | 3.12      | 1.0000      | .0000     | .0000            | 4.0       | .0000 | 11 |
| .0000    | .0008            | 3.02      | 1.2500      | .0000     | .0154            | 4.6       | .0000 | 12 |
| .0000    | .0018            | 3.01      | 1.0000      | .0000     | .0237            | 4.6       | .0220 | 13 |
| .0012    | .0016            | 3.60      | 1.1250      | .0000     | .0273            | 4.6       | .0010 | 14 |
| .0004    | .0018            | 3.21      | 0.7200      | .0000     | .0000            | 5.0       | .0000 | 15 |
| .0004    | .0023            | 3.13      | 0.8319      | .0000     | .0244            | 4.4       | .0030 | 16 |
| .0004    | .0022            | 3.20      | 0.8000      | .0000     | .0395            | 5.0       | .0010 | 17 |
| .0000    | .0030            | 3.42      | 1.0750      | .0000     | .0118            | 5.7       | .0000 | 18 |
| .0000    | .0030            | 3.05      | 0.9500      | .0000     | .0400            | 5.3       | .0000 | 19 |
| .0000    | .0016            | 3.35      | 1.0500      | .0000     | .0000            | 4.9       | .0030 | 20 |
| .0000    | .0008            | 3.30      | 0.5250      | .0000     | .0500            | 4.7       | .0010 | 21 |
| .0000    | .0014            | 2.60      | 0.6000      | .0000     | .0197            | 4.0       | .0000 | 22 |
| .0000    | .0008            | 3.00      | 0.7250      | .0001     | .0507            | 3.9       | .0000 | 23 |
| .0000    | .0010            | 3.80      | 0.3650      | .0000     | .0300            | 4.7       | .0020 | 24 |
| .0000    | .0010            | 3.76      | 0.6250      | .0000     | .0702            | 5.1       | .0000 | 25 |
| .0000    | .0022            | 3.60      | 0.8750      | .0000     | .0117            | 4.4       | .0000 | 26 |
| .0002    | .0030            | 4.00      | 0.6500      | .0000     | .0374            | 5.0       | .0000 | 27 |
| .0000    | .0022            | 3.30      | 1.2000      | .0000     | .0273            | 4.3       | .0000 | 28 |
| .0006    | .0022            | 2.05      | 0.4500      | .0000     | .0390            | 3.6       | .0050 | 29 |
| .0000    | .0010            | 3.37      | 1.4000      | .0000     | .0616            | 4.0       | .0020 | 30 |
| .0001    | .0018            | 3.31      | 0.7856      | .0000     | .0344            | 4.6       | .0008 | 31 |

*Chemical Examination of Water from Bannister Brook below the Framingham Filter-beds.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                 |        | RESIDUE ON EVAPORATION. |                   | AMMONIA. |             |            |            | Chlorine. | NITROGEN As |           | Oxygen Consumed. | Hardness. |
|---------|---------------------|-------------|-----------------|--------|-------------------------|-------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|
|         |                     | Turbidity.  | Sediment.       | Color. | Total.                  | Loss on Ignition. | Free.    | Albuminoid. |            |            |           | Nitrates.   | Nitrites. |                  |           |
|         |                     |             |                 |        |                         |                   |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |
| 14461   | June 11             | V. slight.  | Slight.         | 1.60   | 8.65                    | 3.70              | .0036    | .0332       | .0822      | .0010      | 1.25      | .0480       | .0011     | 1.2090           | 2.3       |
| 14669   | July 22             | Slight.     | Cons., brown.   | 1.30   | 10.40                   | 4.00              | .0066    | .0468       | .0362      | .0106      | 1.57      | .1100       | .0011     | 1.2012           | 2.7       |
| 14802   | Aug. 12             | Slight.     | Slight, yellow. | 1.70   | 10.00                   | 4.80              | .0100    | .0528       | .0484      | .0044      | 1.20      | .0200       | .0003     | 2.2820           | 3.1       |
| 15197   | Sept. 17            | Slight.     | Slight.         | 0.65   | 11.25                   | 3.00              | .0040    | .0194       | .0180      | .0014      | 2.12      | .0630       | .0010     | 0.8513           | 3.1       |
| Av.     | .....               | .....       | .....           | 1.31   | 10.07                   | 3.82              | .0060    | .0380       | .0337      | .0043      | 1.53      | .0602       | .0009     | 1.3309           | 2.3       |

Odor, distinctly vegetable and mouldy. — The samples were collected from the brook, at the first road crossing below the sewage field.

### SEWAGE DISPOSAL AT GARDNER.

The Gardner sewerage system was put in operation about Aug. 1, 1891. At the end of 1895 there were 254 connections with the sewers. The population of the town in 1895 was 9,182. With the exception of roof water used for flushing purposes from a limited number of buildings at the upper ends of the sewers, surface water is excluded. Care was also taken during the construction of the system to exclude ground water by making tight joints between the sewer pipes; but no under-drains were placed beneath the sewers, and there is a considerable quantity of ground water mixed with the sewage. The quantity of sewage is not definitely known, but it is probably not far from 250,000 gallons per day in dry weather.

The tract of land purchased by the town for the disposal of sewage contains 16.9 acres. Much of the material upon this tract was found to be too fine for the filtration of sewage, and as a result the filter-beds are almost wholly artificial, being formed of the porous sand and gravel from a ridge upon this tract. There are 12 thoroughly under-drained filter-beds, having a total area of 1.4 acres; two supplementary beds, which are less porous and not under-drained, having a total area of 0.37 acre; and two other small, under-drained beds, containing together 0.14 of an acre. One of the last beds is

used to receive the sludge from the sludge tank and the other was constructed to receive the discharge from a blow-off located at the lowest point in the inverted syphon which conveys the sewage from the town across the valley of Pond Brook to the filter-beds. This bed, however, has not been used for several years, as it has been found that if clogging occurs in the syphon the sewage backs up in the pipe until sufficient head is obtained to remove the obstruction.

The material of the filter-beds has an effective size of 0.10 to 0.24 millimeters, which is somewhat coarser than that at Marlborough but much finer than that at Framingham. Under-drains beneath the beds are generally 20 feet apart, and at a depth of 4 to 5 feet below the surface of the beds. The sewage when it reaches the disposal area first passes through duplicate separating tanks, having combined capacity of about 10,000 gallons, and overflows through wooden troughs upon the disposal area, as described in the annual report of the Board for 1892, page 580.

The operation of these filter-beds in winter is very different from that in warm weather. During the warmer portions of the year it has been the general custom to apply the sewage to the beds in rotation once in two days, the amount applied depending upon the character of the material of the bed. The deposit which forms upon the surface of the filter is removed, and the surface of the sand raked to a depth of 2 or 3 inches, about once in ten days or two weeks. By this method of operation good purification has been obtained during the warmer portion of the year. In winter weather, when the amount of sewage is greater and it is impossible to remove the solid matter from the beds, the filters become greatly overtaxed, and a short time after severe winter weather sets in all of the beds are covered with the sewage and much of the time a large part of it overflows into the adjoining brook. When the warmer weather comes the surface of the beds becomes uncovered, the sludge which has accumulated during the winter is scraped off and the quality of the effluent rapidly improves.

The area of the filter-beds is inadequate for purification of the sewage of the town, and it will be necessary to prepare a larger number of beds in order to prevent unpurified or partially purified sewage from entering the brook.

During the last two winters the surfaces of the filters have been mowed, and the results obtained have been somewhat better than in previous years, although it appears that the night flow

during the winter finds its way into the brook without purification, and during the coldest weather much of the flow during the day cannot be taken care of by the filters.

During 1894 it was found that just beneath the surface the material had become very compact, and to remedy this the greater part of the filter area was worked over for a depth of 8 or 10 inches. Many small stones were met in this treatment, and holes several feet deep were dug in the filters, in which the stones were buried. As the few inches of material placed over the stones washed away to a certain extent, this process was an unfortunate one, because it gave an

*Chemical Examination of*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE. |                 |                       | RESIDUE ON EVAPORATION. |            |            |                   |            |            |       |
|---------|---------------------|-------------|-----------------|-----------------------|-------------------------|------------|------------|-------------------|------------|------------|-------|
|         |                     | Turbidity.  | Sediment.       | Color.                | TOTAL RESIDUE.          |            |            | LOSS ON IGNITION. |            |            |       |
|         |                     |             |                 |                       | Total.                  | Dissolved. | Suspended. | Total.            | Dissolved. | Suspended. |       |
| 1894.   |                     |             |                 |                       |                         |            |            |                   |            |            |       |
| 1       | 11625               | Jan. 10     | Decided, milky. | Cons., thick.         | .60                     | 26.60      | 20.20      | 6.40              | 15.20      | 9.00       | 6.20  |
| 2       | 11751               | Feb. 13     | Distinct.       | Cons., gray.          | .10                     | 7.90       | 7.30       | 0.60              | 2.10       | 1.70       | 0.40  |
| 3       | 11811               | Feb. 26     | Decided.        | Heavy, gray.          | .40                     | 22.80      | 18.20      | 4.60              | 12.20      | 8.30       | 3.90  |
| 4       | 11881               | Mar. 13     | Decided.        | Heavy, gray.          | .40                     | 23.30      | 18.00      | 5.30              | 13.20      | 8.70       | 4.50  |
| 5       | 11953               | Mar. 27     | Decided.        | Heavy, gray.          | .50                     | 19.00      | 14.40      | 4.00              | 6.60       | 2.60       | 4.00  |
| 6       | 12030               | April 11    | Decided, milky. | Heavy, gray.          | .40                     | 26.00      | 15.60      | 10.40             | 13.00      | 4.40       | 8.60  |
| 7       | 12102               | April 25    | Decided, milky. | Heavy, gray.          | .25                     | 20.00      | 15.00      | 5.00              | 8.80       | 5.20       | 3.60  |
| 8       | 12182               | May 9       | Decided.        | Heavy, gray.          | .60                     | 18.80      | 15.60      | 3.20              | 7.00       | 5.40       | 1.60  |
| 9       | 12354               | June 12     | Decided.        | Cons., white.         | .60                     | 27.40      | 13.60      | 13.80             | 15.80      | 4.60       | 11.20 |
| 10      | 12508               | July 10     | Decided, milky. | Cons., white.         | .60                     | 24.40      | 17.00      | 7.40              | 12.40      | 8.00       | 4.40  |
| 11      | 12682               | Aug. 8      | Thick.          | Heavy, white.         | .50                     | 34.00      | 15.60      | 18.40             | 22.40      | 6.00       | 16.40 |
| 12      | 12944               | Sept. 12    | Thick.          | Heavy, dirty.         | .60                     | 38.60      | 20.00      | 18.60             | 24.80      | 9.60       | 15.20 |
| 13      | 13119               | Oct. 10     | Decided, milky. | Heavy, gray.          | .40                     | 39.00      | 14.80      | 24.20             | 15.20      | 4.90       | 10.30 |
| 14      | 13297               | Nov. 13     | Decided.        | Cons., gray.          | *                       | 29.40      | 21.40      | 8.00              | 18.90      | 12.10      | 6.80  |
| 15      | 13471               | Dec. 11     | Decided.        | Heavy, gray.          | .60                     | 26.30      | 17.60      | 8.70              | 15.50      | 7.70       | 7.80  |
| 16      | Av.                 | .....       | .....           | .....                 | -                       | 27.00      | 16.67      | 10.30             | 14.60      | 6.90       | 7.70  |
| 1895.   |                     |             |                 |                       |                         |            |            |                   |            |            |       |
| 17      | 13637               | Jan. 9      | Decided, milky. | Cons., white.         | .60                     | 25.90      | 17.10      | 8.80              | 16.80      | 9.40       | 7.40  |
| 18      | 13783               | Feb. 7      | Thick.          | Heavy, light colored. | .90                     | 39.10      | 27.10      | 12.00             | 26.90      | 16.60      | 10.30 |
| 19      | 13817               | Feb. 13     | Decided.        | Heavy, gray.          | .50                     | 27.70      | 21.30      | 6.40              | 13.00      | 8.80       | 4.20  |
| 20      | 13894               | Feb. 27     | Thick.          | Heavy, gray.          | .60                     | 46.20      | 23.90      | 22.30             | 32.50      | 13.50      | 19.00 |
| 21      | 13976               | Mar. 13     | Decided.        | Heavy, gray.          | .80                     | 27.90      | 23.50      | 4.40              | 15.70      | 11.60      | 4.10  |
| 22      | 14043               | Mar. 26     | Decided.        | Heavy, light colored. | .50                     | 26.70      | 19.60      | 7.10              | 13.70      | 8.60       | 5.10  |
| 23      | 14126               | April 10    | Decided.        | Cons., gray.          | .20                     | 24.40      | 18.90      | 5.50              | 10.90      | 7.00       | 3.90  |
| 24      | 14297               | May 14      | Decided.        | Heavy.                | .40                     | 39.40      | 18.20      | 21.20             | 22.20      | 6.60       | 15.60 |
| 25      | 14468               | June 12     | Decided, milky. | Heavy, light colored. | .50                     | 29.90      | 17.90      | 12.00             | 16.40      | 7.30       | 9.10  |
| 26      | 14644               | July 17     | Decided.        | Heavy, gray.          | .40                     | 33.40      | 18.20      | 15.20             | 23.00      | 8.40       | 14.60 |
| 27      | 14839               | Aug. 14     | Thick, white.   | Heavy, light colored. | .60                     | 38.20      | 20.60      | 17.60             | 21.00      | 6.80       | 14.20 |
| 28      | 15160               | Sept. 12    | Thick.          | Heavy, light colored. | .70                     | 39.50      | 17.00      | 22.50             | 20.70      | 6.10       | 14.60 |
| 29      | 15390               | Oct. 16     | Thick, white.   | Heavy, white.         | .22                     | 26.40      | 17.40      | 9.00              | 13.70      | 6.20       | 7.50  |
| 30      | 15546               | Nov. 13     | Decided, white. | Heavy.                | .70                     | 35.00      | 23.00      | 12.00             | 20.80      | 11.60      | 9.20  |
| 31      | 15723               | Dec. 11     | Decided.        | Heavy, gray.          | .60                     | 25.40      | 20.80      | 4.60              | 13.20      | 10.40      | 2.80  |
| 1896.   |                     |             |                 |                       |                         |            |            |                   |            |            |       |
| 32      | 15822               | Jan. 1      | Decided, milky. | Cons.                 | .33                     | 22.60      | 18.40      | 4.20              | 9.20       | 6.60       | 2.60  |
| 33      | Av.                 | .....       | .....           | .....                 | .51                     | 32.25      | 19.75      | 12.40             | 18.27      | 7.73       | 9.70  |

\* Too turbid to determine.

opportunity for some of the sewage to reach the effluent pipe in a less purified state than should be the case.

The average analyses, as given in the following tables, indicate that of the sewage filtered, about 89 per cent. of the organic matter, as represented by the albuminoid ammonia, was removed by filtration during 1894, and about 90 per cent. during 1895. For the results of chemical and bacterial analyses, showing the variations at different hours of the day in composition of the summer sewage and measurements of its quantity, a reference is made to page 468 of the annual report for 1894.

*Sewage from Gardner.*

[Parts per 100,000.]

| AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | OXYGEN CONSUMED. |           | IRON.       |           | Hardness. |    |
|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|-------------|-----------|-----------|----|
| Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. | Unfiltered.      | Filtered. | Unfiltered. | Filtered. |           |    |
|          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |             |           |           |    |
| 1.7600   | 0.3080      | 0.1980     | 0.1100     | 2.79      | .0100       | .0140     | 3.9000           | 2.8860    | .0600       | .0360     | 3.0       | 1  |
| 0.4720   | 0.0520      | 0.0420     | 0.0100     | 1.80      | .0400       | .0050     | 0.4624           | 0.4280    | .0230       | .0100     | 1.7       | 2  |
| 1.4400   | 0.0406      | 0.0286     | 0.0120     | 2.41      | .0200       | .0180     | 3.1360           | 2.7200    | .0600       | .0400     | 3.1       | 3  |
| 1.2000   | 0.3160      | 0.1760     | 0.1400     | 2.00      | .0680       | .0140     | 3.4160           | 2.2800    | .0460       | .0280     | 3.1       | 4  |
| 1.1200   | 0.3240      | 0.2640     | 0.0600     | 2.40      | .1560       | .0400     | 3.0030           | 2.2330    | .0740       | .0500     | 3.2       | 5  |
| 1.1200   | 0.4460      | 0.2840     | 0.1620     | 2.42      | .0400       | .0080     | 4.0290           | 2.7255    | .1300       | .0400     | 8.9       | 6  |
| 0.9520   | 0.2540      | 0.1300     | 0.1240     | 2.41      | .1250       | .0100     | 2.1330           | 1.4220    | .0560       | .0200     | 3.4       | 7  |
| 1.8560   | 0.3640      | 0.2000     | 0.1640     | 2.56      | .0050       | .0000     | 2.5830           | 2.0910    | .0800       | .0240     | 3.0       | 8  |
| 2.0800   | 0.4640      | 0.1980     | 0.2660     | 2.00      | .0000       | .0000     | 3.5574           | 1.4476    | -           | -         | 3.5       | 9  |
| 1.9840   | 0.5200      | 0.3100     | 0.2100     | 2.97      | .0000       | .0000     | -                | 1.7248    | -           | -         | 2.9       | 10 |
| 1.0880   | 0.3860      | 0.1480     | 0.2380     | 2.20      | .0000       | .0000     | 3.2340           | 1.7941    | -           | -         | 4.6       | 11 |
| 2.0160   | 0.4560      | 0.2140     | 0.2420     | 3.01      | .0000       | .0000     | 2.5564           | 2.0328    | .0500       | .0200     | 2.3       | 12 |
| 1.9600   | 0.4140      | 0.1620     | 0.2520     | 2.75      | .0000       | .0000     | 3.8000           | 1.2768    | .4700       | .0620     | 2.7       | 13 |
| 0.9920   | 0.2640      | 0.1500     | 0.1140     | 2.20      | .0050       | .0140     | 4.7190           | 3.8610    | .0660       | .0400     | 2.6       | 14 |
| 1.9680   | 0.5420      | 0.3820     | 0.1600     | 2.38      | .0050       | .0020     | 3.5574           | 2.5564    | .0400       | .0260     | 2.9       | 15 |
| 1.5713   | 0.3695      | 0.2020     | 0.1675     | 2.47      | .0208       | .0063     | 3.2724           | 2.1812    | .1067       | .0336     | 3.1       | 16 |
| 0.9920   | 0.3160      | 0.1820     | 0.1340     | 2.12      | .0120       | .0180     | 4.3290           | 2.9640    | .0520       | .0300     | 2.6       | 17 |
| 1.6640   | 2.1120      | 0.9600     | 1.1520     | 2.05      | .0000       | .0200     | 5.2930           | 3.5945    | .0500       | .0250     | 3.9       | 18 |
| 1.5200   | 0.4800      | 0.3700     | 0.1100     | 2.80      | .0050       | .0080     | 3.7600           | 2.1760    | .0400       | .0200     | 2.3       | 19 |
| 2.5920   | 0.6140      | 0.3990     | 0.2180     | 2.40      | .0000       | .0000     | 6.7545           | 4.4082    | .0820       | .0320     | 3.8       | 20 |
| 1.5360   | 0.6460      | 0.3240     | 0.3220     | 2.60      | .0050       | .0200     | 4.7360           | 2.6800    | .0450       | .0420     | 3.2       | 21 |
| 1.2640   | 0.4200      | 0.2200     | 0.2000     | 2.30      | .0000       | .0400     | 2.9260           | 1.6170    | .0700       | .0350     | 3.4       | 22 |
| 0.7680   | 0.2280      | 0.1260     | 0.1020     | 2.75      | .1200       | .0340     | 2.1406           | 1.5400    | .0950       | .0240     | 8.9       | 23 |
| 1.4400   | 0.4920      | 0.1840     | 0.3080     | 1.95      | .0050       | .0000     | 5.5695           | 1.7380    | .1800       | .0660     | 3.1       | 24 |
| 1.3440   | 0.4440      | 0.1900     | 0.2540     | 3.05      | .0000       | .0000     | 3.3930           | 1.5990    | .0600       | .0330     | 3.2       | 25 |
| 2.1120   | 0.6440      | 0.2300     | 0.4140     | 2.70      | .0000       | .0000     | 3.2625           | 2.0625    | .0800       | .0540     | 3.4       | 26 |
| 2.2400   | 0.7140      | 0.3100     | 0.4040     | 3.60      | .0030       | .0000     | 4.9140           | 2.3400    | .1240       | .0740     | 5.1       | 27 |
| 1.6000   | 0.6600      | 0.3200     | 0.3700     | 3.00      | .0000       | .0000     | 6.8250           | 2.4180    | -           | -         | 3.8       | 28 |
| 0.9920   | 0.3460      | 0.1200     | 0.2260     | 3.00      | .0030       | .0000     | 4.2276           | 2.1294    | .0800       | .0380     | 4.3       | 29 |
| 2.6890   | 0.6460      | 0.2760     | 0.3700     | 3.30      | .0030       | .0000     | 4.3360           | 2.0436    | .1040       | .0520     | 3.5       | 30 |
| 1.8900   | 0.4120      | 0.3080     | 0.1040     | 2.98      | .0450       | .0230     | 3.6036           | 2.6910    | .0340       | .0160     | 3.8       | 31 |
| 1.8240   | 0.0240      | 0.0170     | 0.0070     | 2.40      | .1860       | .0400     | 1.8634           | 1.2320    | .0400       | .0240     | 4.9       | 32 |
| 1.6517   | 0.5597      | 0.2621     | 0.2976     | 2.76      | .0225       | .0100     | 4.3167           | 2.2126    | .0775       | .0377     | 3.8       | 33 |

Odor, offensive. — The sewage was collected as it flowed upon the beds.

*Chemical Examination of Effluent from the*

[Parts per 100,000.]

| Number. | Date of Collection | APPEARANCE.         |                       |        | ODOR.                              |                                    | Residue on Evaporation. |
|---------|--------------------|---------------------|-----------------------|--------|------------------------------------|------------------------------------|-------------------------|
|         |                    | Turbidity.          | Sediment.             | Color. | Cold.                              | Hot.                               |                         |
| 1894.   |                    |                     |                       |        |                                    |                                    |                         |
| 1       | 11626 Jan. 11      | Decided, milky.     | Slight.               | 0.20   | Offensive.                         | Offensive.                         | 11.70                   |
| 2       | 11762 Feb. 13      | Distinct.           | Very slight, white.   | 0.30   | Offensive.                         | Offensive.                         | 11.90                   |
| 3       | 11812 Feb. 26      | Very slight, milky. | Very slight.          | 0.10   | Decidedly musty and disagreeable.  | Decidedly musty and disagreeable.  | 11.50                   |
| 4       | 11882 Mar. 13      | Distinct.           | Very slight.          | 0.20   | Offensive.                         | Offensive.                         | 13.50                   |
| 5       | 11954 Mar. 27      | Slight, milky.      | Slight.               | 0.23   | Offensive.                         | Offensive.                         | 22.40                   |
| 6       | 12031 April 11     | Distinct, milky.    | Very slight.          | 0.10   | Decidedly musty.                   | Offensive.                         | 14.10                   |
| 7       | 12103 April 25     | Distinct, milky.    | Cons. floc.           | 0.08   | Decidedly musty.                   | Offensive.                         | 20.50                   |
| 8       | 12183 May 9        | Slight, milky.      | Slight.               | 0.10   | Decidedly musty and disagreeable.  | Decidedly musty and disagreeable.  | 16.40                   |
| 9       | 12359 June 12      | Slight, milky.      | Very slight.          | 0.10   | Decidedly musty.                   | Distinctly mouldy.                 | 24.20                   |
| 10      | 12509 July 10      | Distinct, milky.    | Slight.               | 0.06   | Decidedly musty.                   | Decidedly musty.                   | 22.60                   |
| 11      | 12663 Aug. 8       | Slight, milky.      | Slight, white.        | 0.07   | Distinctly musty and unpleasant.   | Decidedly musty.                   | 24.70                   |
| 12      | 12945 Sept. 12     | Distinct, milky.    | Slight, white.        | 0.10   | Decidedly disagreeable.            | Distinctly disagreeable.           | 13.30                   |
| 13      | 13120 Oct. 10      | Distinct, milky.    | Cons., white.         | 0.08   | Offensive.                         | Offensive.                         | 18.00                   |
| 14      | 13298 Nov. 13      | Distinct, milky.    | Slight, white.        | 0.08   | Offensive.                         | Decidedly musty.                   | 14.00                   |
| 15      | 13472 Dec. 11      | Very slight, milky. | Very slight.          | 0.23   | Decidedly musty and disagreeable.  | Offensive.                         | 12.10                   |
| 16      | Av.                | .....               | .....                 | 0.13   | .....                              | .....                              | 17.05                   |
| 1895.   |                    |                     |                       |        |                                    |                                    |                         |
| 17      | 13638 Jan. 9       | Distinct, milky.    | Slight.               | 0.30   | Distinctly musty and disagreeable. | Decidedly musty and disagreeable.  | 12.30                   |
| 18      | 13784 Feb. 7       | Decided, white.     | Cons., light colored. | 0.38   | Distinctly musty and disagreeable. | Decidedly musty and offensive.     | 12.60                   |
| 19      | 13818 Feb. 13      | Decided, milky.     | Cons., gray.          | 0.60   | Offensive.                         | Offensive.                         | 13.30                   |
| 20      | 13895 Feb. 27      | Decided.            | Cons., gray.          | 1.05   | Offensive.                         | Offensive.                         | 17.00                   |
| 21      | 13977 Mar. 13      | Decided.            | Cons.                 | 1.00   | Offensive.                         | Offensive.                         | 12.60                   |
| 22      | 14044 Mar. 26      | Decided.            | Slight.               | 1.20   | Offensive.                         | Offensive.                         | 11.50                   |
| 23      | 14127 April 10     | Decided.            | Cons., rusty.         | 1.25   | Offensive.                         | Offensive.                         | 14.10                   |
| 24      | 14298 May 14       | Distinct, milky.    | Slight.               | 0.12   | Decidedly musty.                   | Decidedly musty and disagreeable.  | 29.70                   |
| 25      | 14469 June 12      | Distinct, milky.    | Slight.               | 0.07   | Offensive.                         | Offensive.                         | 20.90                   |
| 26      | 14645 July 17      | Distinct.           | Cons.                 | 0.05   | Offensive.                         | Offensive.                         | 19.40                   |
| 27      | 14840 Aug. 14      | Slight, milky.      | Slight.               | 0.10   | Distinctly musty and disagreeable. | Decidedly musty.                   | 20.40                   |
| 28      | 15161 Sept. 12     | Slight.             | Slight.               | 0.08   | Distinctly unpleasant.             | Decidedly musty.                   | 24.20                   |
| 29      | 15391 Oct. 16      | Distinct, white.    | Cons., white.         | 0.10   | Offensive.                         | Offensive.                         | 16.50                   |
| 30      | 15647 Nov. 13      | Slight, milky.      | Slight.               | 0.15   | Decidedly musty and disagreeable.  | Decidedly musty and disagreeable.  | 17.40                   |
| 31      | 16724 Dec. 11      | Distinct.           | Very slight.          | 0.30   | Decidedly disagreeable.            | Decidedly musty.                   | 20.00                   |
| 1896.   |                    |                     |                       |        |                                    |                                    |                         |
| 32      | 15823 Jan. 1       | Slight, milky.      | Slight.               | 0.27   | Offensive.                         | Distinctly musty and disagreeable. | 17.80                   |
| 33      | Av.                | .....               | .....                 | 0.37   | .....                              | .....                              | 18.44                   |

The samples were collected from the main under-

*Main Under-drain of the Gardner Filter-beds.*

[Parts per 100,000.]

| AMMONIA. |              | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |    |
|----------|--------------|-----------|-------------|-----------|------------------|-----------|-------|----|
| Free.    | Alb.-minoid. |           | Nitrates.   | Nitrites. |                  |           |       |    |
| 0.8800   | .0550        | 2.40      | 0.0200      | .0015     | 0.5923           | 3.0       | .0250 | 1  |
| 0.9280   | .0570        | 2.49      | 0.1800      | .0020     | 0.5780           | 2.3       | .0680 | 2  |
| 1.0000   | .0480        | 2.64      | 0.1000      | .0030     | 0.5280           | 2.7       | .0170 | 3  |
| 0.7360   | .0530        | 1.81      | 0.3000      | .0400     | 0.5656           | 3.5       | .0380 | 4  |
| 1.0400   | .0570        | 1.82      | 2.0000      | .1600     | 0.8065           | 5.8       | .0400 | 5  |
| 0.4000   | .0390        | 2.17      | 0.3900      | .0110     | 0.4700           | 2.9       | .0240 | 6  |
| 0.3040   | .0610        | 2.24      | 1.2500      | .0200     | 0.3950           | 6.1       | .0180 | 7  |
| 0.2120   | .0370        | 1.83      | 0.6500      | .1000     | 0.4936           | 4.4       | .0200 | 8  |
| 0.1440   | .0230        | 2.39      | 1.1250      | .0080     | 0.2487           | 5.0       | -     | 9  |
| 0.1200   | .0260        | 2.40      | 1.5000      | .0150     | 0.3041           | 5.4       | .0260 | 10 |
| 0.0600   | .0210        | 1.60      | 2.5000      | .0004     | 0.2464           | 6.9       | .0080 | 11 |
| 0.1840   | .0380        | 1.66      | 0.8000      | .0230     | 0.4312           | 2.6       | .0600 | 12 |
| 0.1560   | .0370        | 1.65      | 1.8750      | .0200     | 0.3040           | 5.6       | .0160 | 13 |
| 0.2440   | .0420        | 2.70      | 0.5800      | .0150     | 0.4430           | 3.1       | .0080 | 14 |
| 0.8000   | .0620        | 2.24      | 0.2300      | .0080     | 0.4297           | 2.6       | .0070 | 15 |
| 0.4170   | .0403        | 2.12      | 0.9367      | .0253     | 0.4304           | 4.2       | .0239 | 16 |
| 0.9440   | .0580        | 2.00      | 0.1400      | .0020     | 0.6240           | 2.7       | .0200 | 17 |
| 0.9920   | .0840        | 1.94      | 0.0650      | .0020     | 0.7268           | 2.7       | .0700 | 18 |
| 0.2960   | .1020        | 2.50      | 0.1000      | .0010     | 0.8040           | 2.5       | .1100 | 19 |
| 1.8580   | .1580        | 2.60      | 0.0150      | .0020     | 1.1889           | 3.8       | .3250 | 20 |
| 1.6000   | .1180        | 2.25      | 0.0350      | .0020     | 1.1160           | 2.7       | .8250 | 21 |
| 1.0580   | .1160        | 2.15      | 0.0350      | .0050     | 0.7981           | 2.7       | .2600 | 22 |
| 0.1440   | .0900        | 2.40      | 0.0900      | .0060     | 0.8816           | 2.6       | .4900 | 23 |
| 0.2880   | .0260        | 2.00      | 2.4500      | .0030     | 0.3278           | 8.3       | .0370 | 24 |
| 0.1960   | .0830        | 2.05      | 0.9600      | .0130     | 0.3916           | 4.3       | .2600 | 25 |
| 0.2200   | .0330        | 2.80      | 1.0750      | .0040     | 0.3525           | 6.6       | .0520 | 26 |
| 0.2120   | .0320        | 2.90      | 1.1000      | .0040     | 0.3744           | 4.7       | .0430 | 27 |
| 0.5040   | .0440        | 3.80      | 1.3750      | .0100     | 1.0920           | 4.3       | .0880 | 28 |
| 0.3600   | .0190        | 3.05      | 0.6500      | .0130     | 0.3136           | 3.6       | .0200 | 29 |
| 0.0320   | .0350        | 3.15      | 0.4500      | .0200     | 0.4173           | 3.6       | .0380 | 30 |
| 0.7760   | .0280        | 3.00      | 0.8000      | .0750     | 0.5460           | 4.9       | .0660 | 31 |
| 0.6400   | .0880        | 2.30      | 0.6500      | .0500     | 0.4605           | 3.9       | .0530 | 32 |
| 0.5030   | .0562        | 2.63      | 0.7550      | .0119     | 0.6039           | 4.2       | .1369 | 33 |

drain at the point where it discharges into the brook.



*Chemical Examination of Water from Pond Brook above the Gardner Filter-beds.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.     |                |        | RESIDUE ON EVAPORATION. |                   | AMMONIA.    |        |            |            | Chlorine. | NITROGEN AS |       | Oxygen Consumed | Hardness. |
|---------|---------------------|-----------------|----------------|--------|-------------------------|-------------------|-------------|--------|------------|------------|-----------|-------------|-------|-----------------|-----------|
|         |                     | Turbidity.      | Sediment.      | Color. | Total.                  | Loss on Ignition. | Albuminoid. |        |            |            |           |             |       |                 |           |
|         |                     |                 |                |        |                         |                   | Free.       | Total. | Dissolved. | Suspended. |           |             |       |                 |           |
| 14470   | June 12             | Slight, milky.  | Slight.        | .30    | 42.00                   | 15.60             | .0248       | .0328  | .0264      | .0064      | 9.40      | .0650       | .0140 | 0.5054          | 14.4      |
| 14646   | July 17             | Slight.         | Slight.        | .28    | 31.60                   | 11.10             | .0080       | .0220  | .0204      | .0016      | 7.40      | .2100       | .0042 | 0.3225          | 13.2      |
| 14841   | Aug. 14             | Slight, milky.  | V. slight.     | .25    | 29.10                   | 3.90              | .0056       | .0216  | .0192      | .0024      | 7.00      | .0800       | .0022 | 0.4524          | 10.9      |
| 15162   | Sept. 12            | Decided, milky. | Cons., earthy. | .70    | 27.50                   | -                 | .0720       | .0500  | .0280      | .0220      | 6.00      | .0250       | .0012 | 1.1310          | 8.4       |
| Av.     | .....               | .....           | .....          | .38    | 32.55                   | 10.20             | .0276       | .0316  | .0235      | .0081      | 7.45      | .0950       | .0054 | 0.6028          | 11.7      |

Iron, .1100. Odor, musty or offensive. — The samples were collected from the brook, above the point where it is crossed by the main sewer leading to the filter-beds.

*Chemical Examination of Water from Pond Brook below the Gardner Filter-beds.*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.        |                    |        | RESIDUE ON<br>EVAPORA-<br>TION. |                      | AMMONIA.     |        |            |                 | Chlorine. | NITROGEN<br>AS |       | Oxygen Consumed. | Hardness. |
|---------|---------------------|--------------------|--------------------|--------|---------------------------------|----------------------|--------------|--------|------------|-----------------|-----------|----------------|-------|------------------|-----------|
|         |                     | Turbidity.         | Sediment.          | Color. | Total.                          | Loss on<br>Ignition. | All-aminoid. |        |            |                 |           |                |       |                  |           |
|         |                     |                    |                    |        |                                 |                      | Free.        | Total. | Dissolved. | Sus-<br>pended. |           |                |       |                  |           |
|         | 1895.               |                    |                    |        |                                 |                      |              |        |            |                 |           |                |       |                  |           |
| 14471   | June 12             | Slight,<br>milky.  | Slight.            | .25    | 31.00                           | 14.30                | .0368        | .0332  | .0280      | .0052           | 7.00      | .2500          | .0140 | 0.4797           | 10.5      |
| 14647   | July 17             | V. slight.         | Slight.            | .25    | 26.60                           | 11.90                | .0192        | .0212  | .0200      | .0012           | 6.20      | .0850          | .0025 | 0.4237           | 10.0      |
| 14842   | Aug. 14             | V. slight.         | V. slight.         | .20    | 25.30                           | 4.90                 | .0192        | .0236  | .0204      | .0032           | 5.60      | .1840          | .0050 | 0.4368           | 8.7       |
| 15163   | Sept. 12            | Decided,<br>milky. | Slight,<br>earthy. | .70    | 25.20                           | -                    | .0960        | .0300  | .0240      | .0060           | 5.65      | .0900          | .0060 | 1.2450           | 7.7       |
| Av.     | .....               | .....              | .....              | .35    | 27.02                           | 10.37                | .0428        | .0270  | .0231      | .0039           | 6.11      | .1522          | .0069 | 0.6970           | 9.2       |

Iron, .0857. Odor, distinctly musty or unpleasant. — The samples were collected from the brook, below the filter-beds and below the point where effluent from the filter-beds enters the stream.

## SEWAGE DISPOSAL OF MARLBOROUGH.

The sewerage system of the city of Marlborough (population in 1895, 14,977) was completed late in 1891, and at the end of 1895 there were about 1,252 connections, including all of the larger buildings, such as hotels, factories, etc.; the total length of sewers was

22.07 miles. The so-called "separate system" was adopted, but no under-drains were laid beneath the sewers, and a large amount of ground water enters them at certain seasons of the year.

As the sewage arrives at the disposal field it passes through duplicate separating tanks and screens before passing into the distributing pipes. Each tank is about 25 feet long,  $6\frac{1}{2}$  feet wide and 6 feet deep. The screens are of wire, and have a 1-inch mesh. The sludge which is deposited in the tanks flows by gravity to beds prepared for this purpose.

The total area of the tract bought by the city is 62.7 acres. Upon this tract 13 sewage beds with a total area of 9.6 acres and 6 sludge beds with a total area of 1.7 acres have been prepared for the disposal of the sewage and sludge. The material of the beds is finer than that of Framingham or Gardner, and has an effective size of 0.12 to 0.14 millimeters. The area has a moderate slope toward a small brook, and is from 7 to 22 feet above it. The beds are thoroughly under-drained by means of parallel lines of pipe, 50 feet apart and about 6 feet beneath the surface. All these drains discharge into the brook before mentioned.

The sewage is ordinary city sewage, varying in strength from time to time with the amount of ground water which enters the sewers. The quantity of sewage is not known, but the dry weather flow is probably in the neighborhood of 500,000 gallons per day.

For the results of chemical and bacterial analyses of hourly samples, showing the variation in the summer sewage as it flowed into the settling tanks, reference is made to page 467 of the annual report for 1894 and page 455 of this volume. In the same tables hourly measurements of flow will also be found. Each bed generally receives the sewage for twenty-four hours, unless the quantity of sewage is so great as to cause it to overflow its banks; and the sewage disappears from the surface in from one to ten days after receiving the dose.

The surfaces are ploughed and harrowed about once in three weeks, the sludge being raked from the surface before the bed is ploughed. After this treatment the sewage disappears from the bed rapidly, the length of time taken for it to pass through the filter increasing with each application of sewage.

In the fall the surfaces of the beds are furrowed with a disc harrow and in the winter the sewage is applied to the beds for not more than half a day at a time. The capacity of the field, however,

is insufficient for the flow during wet weather. At such times a portion of the sewage flows directly into the brook.

The separating tanks are emptied once in two weeks, and the sludge, after being dried on the beds prepared for the purpose, is carted away by the farmers for use upon the land as a fertilizer.

It has not been the custom to employ a man constantly in caring for the beds, as in the cases of Brockton, Framingham and Gardner, but to employ a man living in the neighborhood to attend to changing the flow of sewage from bed to bed and to remove the scum from the surface of the beds, paying him by the hour for the

### Chemical Examination of

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.     |                  |        | RESIDUE ON EVAPORATION. |            |            |                   |            |            |
|---------|---------------------|-----------------|------------------|--------|-------------------------|------------|------------|-------------------|------------|------------|
|         |                     | Turbidity.      | Sediment.        | Color. | TOTAL RESIDUE.          |            |            | LOSS ON IGNITION. |            |            |
|         |                     |                 |                  |        | Total.                  | Dissolved. | Suspended. | Total.            | Dissolved. | Suspended. |
| 1894.   |                     |                 |                  |        |                         |            |            |                   |            |            |
| 1       | 11619 Jan. 9        | Decided, thick. | Heavy, dark.     | 0.60   | 56.80                   | 33.80      | 23.00      | 27.20             | 8.80       | 18.40      |
| 2       | 11768 Feb. 14       | Thick.          | Heavy.           | 0.70   | 57.60                   | 34.20      | 23.40      | 28.20             | 9.00       | 19.20      |
| 3       | 11814 Feb. 27       | Thick.          | Heavy, gray.     | 1.50   | 46.40                   | 32.80      | 13.60      | 20.40             | 10.00      | 10.40      |
| 4       | 11886 Mar. 13       | Decided.        | Cons., gray.     | 0.30   | 32.40                   | 26.60      | 5.80       | 12.00             | 6.80       | 5.20       |
| 5       | 11960 Mar. 27       | Decided.        | Heavy, gray.     | 0.50   | 37.80                   | 30.00      | 7.80       | 10.00             | 4.20       | 5.80       |
| 6       | 12038 April 14      | Decided.        | Heavy, gray.     | 0.33   | 40.00                   | 25.00      | 15.00      | 10.20             | 7.00       | 3.20       |
| 7       | 12111 April 25      | Decided.        | Heavy, gray.     | 0.60   | 32.60                   | 24.80      | 7.80       | 11.60             | 5.20       | 6.40       |
| 8       | 12189 May 9         | Decided, milky. | Heavy, gray.     | 0.60   | 37.80                   | 29.40      | 8.40       | 15.20             | 8.80       | 6.40       |
| 9       | 12362 June 11       | Thick.          | Heavy, dark.     | 0.60   | 74.20                   | 57.20      | 17.00      | 24.20             | 14.40      | 9.80       |
| 10      | 12522 July 10       | Thick, dark.    | Heavy, black.    | 1.50   | 101.40                  | 53.40      | 48.00      | 54.40             | 18.00      | 36.40      |
| 11      | 12720 Aug. 9        | Thick.          | Heavy, dark.     | *      | 57.40                   | 33.60      | 23.80      | 28.60             | 6.40       | 22.20      |
| 12      | 12946 Sept. 12      | Thick.          | V. heavy, dark.  | 0.70   | 70.60                   | 28.40      | 42.20      | 47.80             | 11.60      | 36.20      |
| 13      | 13126 Oct. 12       | Decided.        | Heavy, gray.     | 1.50   | 88.40                   | 29.00      | 59.40      | 56.20             | 7.20       | 49.00      |
| 14      | 13316 Nov. 14       | Decided.        | Heavy, gray.     | 0.80   | 47.40                   | 31.80      | 15.60      | 19.20             | 8.00       | 11.20      |
| 15      | 13481 Dec. 13       | Decided.        | Heavy, brown.    | 2.00   | 75.80                   | 40.80      | 35.10      | 35.80             | 8.20       | 26.60      |
| 16      | Av. ....            | .....           | .....            | -      | 61.11                   | 35.34      | 25.77      | 29.57             | 9.42       | 20.13      |
| 1895.   |                     |                 |                  |        |                         |            |            |                   |            |            |
| 17      | 13649 Jan. 11       | Decided.        | Heavy, gray.     | 0.60   | 37.10                   | 25.50      | 11.60      | 13.80             | 4.10       | 9.70       |
| 18      | 13715 Jan. 23       | Decided.        | Heavy, gray.     | 0.50   | 40.10                   | 29.30      | 10.80      | 16.70             | 7.90       | 8.80       |
| 19      | 13857 Feb. 18       | Thick.          | Heavy, brown.    | -      | 93.10                   | 47.80      | 45.30      | 57.40             | 18.90      | 38.50      |
| 20      | 13901 Feb. 28       | Decided.        | Cons., dirty.    | 0.18   | 42.00                   | 23.30      | 18.70      | 22.60             | 5.40       | 17.20      |
| 21      | 13984 Mar. 15       | Decided.        | Heavy, gray.     | 0.20   | 24.50                   | 21.10      | 3.40       | 7.50              | 5.40       | 2.10       |
| 22      | 14049 Mar. 28       | Thick.          | Heavy, white.    | 0.50   | 47.80                   | 27.80      | 20.00      | 22.40             | 6.70       | 15.70      |
| 23      | 14135 April 10      | Decided.        | Cons.            | 0.40   | 35.50                   | 26.20      | 9.30       | 13.40             | 7.50       | 5.90       |
| 24      | 14364 May 22        | Decided.        | Heavy.           | 0.90   | 49.40                   | 35.80      | 13.60      | 22.80             | 12.00      | 10.80      |
| 25      | 14475 June 17       | Distinct.       | Slight.          | 0.55   | 24.60                   | 23.00      | 1.60       | 4.90              | 4.30       | 0.60       |
| 26      | 14649 July 17       | Decided.        | Cons., gray.     | 0.23   | 27.80                   | 22.20      | 5.60       | 10.20             | 5.60       | 4.60       |
| 27      | 14813 Aug. 11       | Decided.        | V. heavy, black. | 0.40   | 78.60                   | 23.60      | 55.00      | 31.20             | 5.00       | 26.20      |
| 28      | 15215 Sept. 17      | Thick.          | Heavy, dark.     | -      | 60.70                   | 45.50      | 15.20      | 26.70             | 14.30      | 12.40      |
| 29      | 15397 Oct. 16       | Decided, milky. | Heavy, grayish.  | 0.40   | 37.40                   | 28.00      | 9.40       | 13.50             | 6.10       | 7.40       |
| 30      | 15551 Nov. 14       | Distinct.       | Cons., white.    | 0.10   | 23.00                   | 22.20      | 0.80       | 8.00              | 7.80       | 0.20       |
| 31      | 15727 Dec. 11       | Decided.        | Heavy.           | 0.60   | 32.60                   | 26.00      | 6.60       | 13.80             | 9.20       | 4.60       |
| 32      | 15811 Dec. 26       | Distinct.       | Cons.            | 0.30   | 29.80                   | 22.80      | 7.00       | 10.00             | 4.40       | 5.60       |
| 33      | Av. ....            | .....           | .....            | -      | 42.54                   | 28.19      | 14.35      | 17.73             | 7.80       | 9.93       |

\* Too turbid to determine.

time spent on the work. The cost of all work done on the beds during 1895 amounted to about \$1,000.

At times there has been considerable odor from the sludge beds and around the outlet of the carriers, but this has been overcome somewhat by the use of lime. The average analyses for the year 1894, as presented in the following tables, indicate that about 95 per cent. of the organic matter, as represented by the albuminoid ammonia, was removed from that portion of the sewage which was applied to the beds during that year, and during 1895 the percentage of organic matter removed was about 93.

*Sewage from Marlborough.*

[Parts per 100,000.]

| AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |          | OXYGEN CONSUMED. |           | IRON.       |           | Hardness. |    |
|----------|-------------|------------|------------|-----------|-------------|----------|------------------|-----------|-------------|-----------|-----------|----|
| Free.    | ALBUMINOID. |            |            |           | Nitrate.    | Nitrite. | Unfiltered.      | Filtered. | Unfiltered. | Filtered. |           |    |
|          | Total.      | Dissolved. | Suspended. |           |             |          |                  |           |             |           |           |    |
| 8.5200   | 0.9080      | .2640      | 0.6440     | 6.62      | .0000       | .0800    | 7.0590           | 3.3150    | .2000       | .0560     | 7.4       | 1  |
| 8.5200   | 0.7720      | .3020      | 0.4700     | 7.57      | .0000       | .0000    | 5.1840           | 2.5440    | .2000       | .0800     | 6.6       | 2  |
| 1.9200   | 0.5800      | .2560      | 0.3240     | 5.60      | .0000       | .0000    | 4.9200           | 3.0000    | .2640       | .0800     | 6.3       | 3  |
| 1.0400   | 0.2860      | .1320      | 0.1540     | 4.18      | .3500       | .0600    | 3.6800           | 2.0640    | .1400       | .0400     | 7.4       | 4  |
| 2.0800   | 0.4780      | .2160      | 0.2620     | 5.98      | .1360       | .1800    | 3.3495           | 1.5400    | .1300       | .0300     | 7.3       | 5  |
| 0.9120   | 0.2180      | .0820      | 0.1360     | 4.38      | .2500       | .0800    | 3.2400           | 1.1600    | .4700       | .0720     | 7.4       | 6  |
| 1.2480   | 0.4840      | .1640      | 0.3200     | 5.19      | .0000       | .0000    | 1.9750           | 1.2087    | .1560       | .0600     | 6.9       | 7  |
| 1.6320   | 0.2920      | .2240      | 0.0680     | 5.64      | .0000       | .0000    | 3.2800           | 2.2140    | .1600       | .0840     | 7.1       | 8  |
| 3.6000   | 0.5900      | .2480      | 0.3120     | 2.38      | .0000       | .0000    | 4.7509           | 2.7335    | -           | -         | 7.7       | 9  |
| 9.6000   | 1.5800      | .5100      | 1.0700     | 12.30     | .0000       | .0000    | -                | 3.8654    | -           | -         | 8.9       | 10 |
| 3.2000   | 0.9000      | .3000      | 0.6000     | 8.00      | .0000       | .0000    | 5.2745           | 1.6170    | -           | -         | 6.3       | 11 |
| 2.2400   | 0.5200      | .1740      | 0.3460     | 3.97      | .0000       | .0000    | 2.3408           | 1.8172    | .1800       | .0900     | 4.2       | 12 |
| 4.0320   | 1.3580      | .4200      | 0.9380     | 6.40      | .0000       | .0000    | 8.7400           | 2.9200    | .2400       | .0500     | 9.3       | 13 |
| 2.8880   | 0.4700      | .2180      | 0.2520     | 6.90      | .0000       | .0000    | 4.8750           | 1.9890    | .2200       | .0700     | 8.6       | 14 |
| 3.1360   | 1.1060      | .3060      | 0.8000     | 11.44     | .0300       | .0800    | 7.6615           | 2.5410    | .1950       | .0450     | 8.1       | 15 |
| 3.2507   | 0.7586      | .2700      | 0.4886     | 6.65      | .0332       | .0267    | 5.0142           | 2.3980    | .2083       | .0640     | 7.4       | 16 |
| 1.8560   | 0.4420      | .1720      | 0.2700     | 6.11      | .0030       | .1000    | 3.6735           | 1.3430    | .0880       | .0270     | 7.4       | 17 |
| 2.0800   | 0.4480      | .1520      | 0.2960     | 6.66      | .0000       | .0850    | 3.2390           | 1.6195    | .1050       | .0300     | 8.1       | 18 |
| 4.8800   | 1.5800      | .6600      | 0.9200     | 7.15      | .0000       | .0000    | 11.1540          | 5.0310    | .2200       | .0740     | 7.1       | 19 |
| 0.8280   | 0.2940      | .0400      | 0.2540     | 3.80      | .2750       | .0600    | 2.6860           | 1.2008    | .1420       | .0650     | 10.6      | 20 |
| 0.8480   | 0.1320      | .0400      | 0.0920     | 3.35      | .4750       | .0370    | 1.8825           | 0.7742    | .0570       | .0200     | 7.0       | 21 |
| 1.7600   | 0.5240      | .2280      | 0.2960     | 5.00      | .0000       | .0000    | 4.3890           | 1.7325    | .0900       | .0400     | 7.0       | 22 |
| 1.0400   | 0.3080      | .1160      | 0.1920     | 4.60      | .1200       | .3090    | 2.5025           | 1.5246    | .1200       | .0370     | 7.3       | 23 |
| 2.4000   | 0.5680      | .2620      | 0.3060     | 7.35      | .0050       | .0000    | 5.5880           | 2.7132    | .1500       | .0800     | 7.9       | 24 |
| 4.8640   | 0.1440      | .1020      | 0.0420     | 5.00      | .0000       | .0000    | 1.4820           | 1.0920    | .1880       | .1850     | 6.7       | 25 |
| 0.3920   | 0.1160      | .0600      | 0.0560     | 4.00      | .0800       | .0260    | 0.5250           | 0.3375    | .0900       | .0540     | 8.0       | 26 |
| 0.6400   | 0.5800      | .0760      | 0.5040     | 3.60      | .0070       | .0000    | 5.3040           | 1.4040    | .3600       | -         | 9.4       | 27 |
| 4.8640   | 0.6160      | .2880      | 0.3280     | 9.65      | .0000       | .0000    | 6.7860           | 3.9390    | .2850       | .0750     | 5.4       | 28 |
| 0.9920   | 0.4020      | .1480      | 0.2540     | 5.40      | .0000       | .0000    | 3.1590           | 1.8720    | .1220       | .0550     | 8.4       | 29 |
| 0.2560   | 0.0420      | .0100      | 0.0320     | 3.45      | .4250       | .0400    | 0.0970           | 0.6630    | .0540       | .0260     | 8.4       | 30 |
| 2.0480   | 0.3980      | .1740      | 0.1240     | 4.60      | .0000       | .0000    | 2.9454           | 1.1700    | -           | -         | 7.8       | 31 |
| 1.7600   | 0.3460      | .1220      | 0.2240     | 4.22      | .0000       | .0000    | 1.3090           | 0.9240    | .1100       | .0320     | 7.9       | 32 |
| 1.9357   | 0.4048      | .1547      | 0.2501     | 5.25      | .0845       | .0422    | 4.7519           | 1.7036    | .1336       | .0565     | 7.7       | 33 |

Odor, offensive. — The samples were collected from the separating tanks, and represent the sewage after a portion of the suspended matter had been separated from it.

*Chemical Examination of Effluent from the*  
[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                     |        | ODOR.                                |                                    | Residue on Evaporation. |
|---------|---------------------|---------------------|---------------------|--------|--------------------------------------|------------------------------------|-------------------------|
|         |                     | Turbidity.          | Sediment.           | Color. | Cold.                                | Hot.                               |                         |
|         | <b>1894.</b>        |                     |                     |        |                                      |                                    |                         |
| 1       | 11820 Jan. 9        | Slight, milky.      | None.               | .04    | Decidedly musty.                     | Decidedly musty.                   | 27.90                   |
| 2       | 11821 Jan. 9        | None.               | None.               | .01    | Decidedly musty.                     | Decidedly musty.                   | 30.50                   |
| 3       | 11769 Feb. 14       | Very slight.        | V. slight.          | .00    | Decidedly musty.                     | Decidedly musty.                   | 28.15                   |
| 4       | 11770 Feb. 14       | Slight, milky.      | Slight.             | .00    | Decidedly musty.                     | Decidedly musty.                   | 28.90                   |
| 5       | 11815 Feb. 27       | Slight, milky.      | Slight, rusty.      | .08    | Offensive.                           | Decidedly musty and disagreeable.  | 25.30                   |
| 6       | 11816 Feb. 27       | Slight, milky.      | Slight, rusty.      | .02    | Decidedly musty.                     | Decidedly musty and disagreeable.  | 26.20                   |
| 7       | 11887 Mar. 13       | Slight, milky.      | None.               | .15    | Offensive.                           | Offensive.                         | 22.70                   |
| 8       | 11888 Mar. 13       | Distinct.           | Very slight.        | .25    | Offensive.                           | Offensive.                         | 23.60                   |
| 9       | 11961 Mar. 27       | Very slight, milky. | None.               | .00    | Decidedly musty and disagreeable.    | Offensive.                         | 26.25                   |
| 10      | 11962 Mar. 27       | Very slight, milky. | None.               | .02    | Offensive.                           | Offensive.                         | 25.65                   |
| 11      | 12039 April 14      | Very slight.        | None.               | .02    | Decidedly musty.                     | Decidedly musty.                   | 26.00                   |
| 12      | 12040 April 14      | Very slight.        | Cons., sand.        | .01    | Distinctly musty.                    | Decidedly musty.                   | 26.70                   |
| 13      | 12112 April 25      | Very slight.        | Very slight, white. | .08    | Decidedly musty.                     | Offensive.                         | 27.40                   |
| 14      | 12113 April 25      | Very slight.        | Very slight.        | .04    | Decidedly musty.                     | Decidedly musty.                   | 26.50                   |
| 15      | 12190 May 9         | Very slight.        | Very slight.        | .03    | Offensive.                           | Decidedly musty.                   | 27.20                   |
| 16      | 12191 May 9         | Slight, milky.      | Slight.             | .04    | Offensive.                           | Offensive.                         | 27.70                   |
| 17      | 12363 June 11       | Distinct, milky.    | Slight, white.      | .45    | Offensive.                           | Decidedly musty and disagreeable.  | 26.60                   |
| 18      | 12364 June 11       | Very slight.        | Very slight.        | .10    | Decidedly disagreeable.              | Distinctly musty and disagreeable. | 31.00                   |
| 19      | 12523 July 10       | Distinct, milky.    | Slight, rusty.      | .10    | Decidedly disagreeable.              | Decidedly musty.                   | 44.50                   |
| 20      | 12524 July 10       | Distinct, milky.    | Slight, rusty.      | .25    | Decidedly disagreeable and musty.    | Distinctly musty and disagreeable. | 46.50                   |
| 21      | 12721 Aug. 9        | Distinct, white.    | Slight, white.      | .20    | Distinctly musty, very disagreeable. | Distinctly musty and disagreeable. | 44.20                   |
| 22      | 12722 Aug. 9        | Decided.            | Cons.               | .30    | Distinctly musty and disagreeable.   | Distinctly musty and offensive.    | 30.90                   |
| 23      | 12947 Sept. 12      | Decided, milky.     | Slight.             | .30    | Decidedly disagreeable.              | Distinctly disagreeable.           | 43.40                   |
| 24      | 12948 Sept. 12      | Decided, milky.     | Slight, white.      | .30    | Decidedly disagreeable.              | Decidedly offensive.               | 37.30                   |
| 25      | 13127 Oct. 12       | Distinct, milky.    | Cons., rusty.       | .18    | Offensive.                           | Offensive.                         | 41.20                   |
| 26      | 13128 Oct. 12       | Slight.             | Slight, gray.       | .10    | Offensive.                           | Offensive.                         | 35.10                   |
| 27      | 13317 Nov. 14       | Distinct.           | Slight, white.      | .15    | Offensive.                           | Offensive.                         | 29.10                   |
| 28      | 13318 Nov. 14       | Slight.             | Very slight.        | .08    | Offensive.                           | Decidedly musty and disagreeable.  | 33.00                   |
| 29      | 13482 Dec. 13       | Distinct, white.    | Cons., white.       | .03    | Decidedly musty and disagreeable.    | Offensive.                         | 32.50                   |
| 30      | 13483 Dec. 13       | Slight.             | Cons.               | .05    | Decidedly musty and disagreeable.    | Decidedly musty and disagreeable.  | 26.40                   |
| 31      | Av. ....            | .....               | .....               | .13    | .....                                | .....                              | 32.15                   |

*Under-drains of the Marlborough Filler-beds.*

[Parts per 100,000.]

| AMMONIA. |              | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |    |
|----------|--------------|-----------|-------------|-----------|------------------|-----------|-------|----|
| Free.    | Alb.-minold. |           | Nitrates.   | Nitrites. |                  |           |       |    |
| 0.3600   | .0130        | 4.23      | 1.6000      | .0070     | .1911            | 9.1       | .0070 | 1  |
| 0.3800   | .0060        | 5.42      | 1.7500      | .0050     | .1014            | 9.0       | .0000 | 2  |
| 0.4400   | .0170        | 5.18      | 0.9000      | .0030     | .1944            | 7.7       | .0000 | 3  |
| 0.4400   | .0200        | 5.77      | 1.1000      | .0070     | .2136            | 8.9       | .0000 | 4  |
| 0.4720   | .0190        | 4.65      | 0.7500      | .0130     | .2840            | 8.0       | .0700 | 5  |
| 0.4600   | .0140        | 4.61      | 0.7800      | .0070     | .2368            | 7.3       | .0280 | 6  |
| 0.3120   | .0110        | 3.83      | 0.5800      | .0340     | .2384            | 6.4       | .0600 | 7  |
| 0.3600   | .0190        | 3.94      | 0.6000      | .0200     | .2640            | 7.6       | .1000 | 8  |
| 0.2480   | .0170        | 4.40      | 1.0000      | .0100     | .1694            | 8.1       | .0125 | 9  |
| 0.5200   | .0130        | 4.41      | 1.0000      | .0140     | .1617            | 7.8       | .0250 | 10 |
| 0.4600   | .0210        | 4.20      | 0.9500      | .0130     | .2120            | 7.1       | .0020 | 11 |
| 0.2400   | .0080        | 4.21      | 1.0500      | .0080     | .1744            | 8.3       | .0020 | 12 |
| 0.2400   | .0270        | 4.38      | 1.1000      | .0130     | .1896            | 7.6       | .0080 | 13 |
| 0.1720   | .0140        | 4.38      | 1.0000      | .0160     | .1635            | 7.7       | .0180 | 14 |
| 0.2320   | .0270        | 5.00      | 0.7000      | .0100     | .2870            | 7.0       | .0100 | 15 |
| 0.3600   | .0350        | 4.96      | 0.7500      | .0080     | .3485            | 6.9       | .0120 | 16 |
| 0.7000   | .0680        | 5.44      | 0.3500      | .0180     | .5197            | 7.0       | -     | 17 |
| 0.4000   | .0300        | 5.58      | 0.9500      | .0050     | .2487            | 8.6       | -     | 18 |
| 0.6000   | .0500        | 6.33      | 1.6600      | .0180     | .3888            | 12.6      | .0650 | 19 |
| 0.5200   | .0440        | 6.39      | 0.3000      | .0110     | .3811            | 12.6      | .0460 | 20 |
| 0.5800   | .0700        | 7.00      | 2.5000      | .0120     | .5505            | 9.3       | .0300 | 21 |
| 1.0000   | .0830        | 6.40      | 0.8000      | .0150     | .6391            | 6.3       | .0750 | 22 |
| 0.5920   | .0810        | 7.80      | 1.5000      | .0800     | .8008            | 8.4       | .0300 | 23 |
| 0.5160   | .0670        | 7.59      | 1.2500      | .0600     | .6468            | 7.0       | .0450 | 24 |
| 0.3840   | .0350        | 7.42      | 2.0800      | .0080     | .3078            | 8.9       | .2750 | 25 |
| 0.5400   | .0380        | 7.00      | 1.3000      | .0140     | .3610            | 8.1       | .1100 | 26 |
| 0.8960   | .0660        | 5.90      | 0.9800      | .0120     | .5850            | 6.9       | .0170 | 27 |
| 0.4560   | .0250        | 6.38      | 1.1600      | .0120     | .3315            | 8.6       | .0150 | 28 |
| 0.3200   | .0300        | 5.75      | 1.2400      | .0030     | .3080            | 8.6       | .0150 | 29 |
| 0.6400   | .0330        | 4.93      | 0.8000      | .0040     | .3103            | 7.0       | .0230 | 30 |
| 0.4983   | .0375        | 5.69      | 1.1281      | .0159     | .3566            | 8.3       | .0366 | 31 |

*Chemical Examination of Effluent from the*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.            |                 |        | ODOR.                              |                                   | Residue on Evaporation. |
|---------|---------------------|------------------------|-----------------|--------|------------------------------------|-----------------------------------|-------------------------|
|         |                     | Turbidity.             | Sediment.       | Color. | Cold.                              | Hot.                              |                         |
|         | <b>1895.</b>        |                        |                 |        |                                    |                                   |                         |
| 1       | 13650 Jan. 11       | Slight.                | Very slight.    | 0.05   | Decidedly musty and disagreeable.  | Decidedly musty and disagreeable. | 26.10                   |
| 2       | 13651 Jan. 11       | Slight.                | Very slight.    | 0.05   | Distinctly musty and disagreeable. | Decidedly musty and disagreeable. | 27.20                   |
| 3       | 13716 Jan. 23       | Slight, milky.         | Cons., reddish. | 0.03   | Offensive.                         | Offensive.                        | 28.50                   |
| 4       | 13717 Jan. 23       | Slight, milky.         | Very slight.    | 0.10   | Offensive.                         | Offensive.                        | 25.80                   |
| 5       | 13858 Feb. 18       | Slight.                | Cons., white.   | 0.18   | Decidedly musty and disagreeable.  | Offensive.                        | 30.80                   |
| 6       | 13859 Feb. 18       | Very slight.           | Slight.         | 0.15   | Decidedly musty and disagreeable.  | Decidedly musty and disagreeable. | 29.30                   |
| 7       | 13902 Feb. 28       | Distinct, slight scum. | Slight.         | 0.20   | Offensive.                         | Offensive.                        | 28.00                   |
| 8       | 13903 Feb. 28       | Decided, white.        | Slight.         | 0.65   | Offensive.                         | Offensive.                        | 27.20                   |
| 9       | 13985 Mar. 15       | Distinct.              | Slight.         | 0.18   | Offensive.                         | Offensive.                        | 19.30                   |
| 10      | 13986 Mar. 15       | Distinct.              | Slight.         | 0.15   | Offensive.                         | Offensive.                        | 19.30                   |
| 11      | 14050 Mar. 26       | Slight, milky.         | Slight.         | 0.10   | Decidedly musty and disagreeable.  | Offensive.                        | 20.40                   |
| 12      | 14051 Mar. 26       | Distinct.              | Slight.         | 0.40   | Decidedly musty and disagreeable.  | Offensive.                        | 20.50                   |
| 13      | 14136 April 10      | Distinct.              | Slight.         | 0.05   | Decidedly musty and disagreeable.  | Offensive.                        | 31.70                   |
| 14      | 14137 April 10      | Slight.                | Slight, rusty.  | 0.04   | Decidedly musty and disagreeable.  | Offensive.                        | 28.20                   |
| 15      | 14365 May 22        | Distinct.              | Slight.         | 0.10   | Offensive.                         | Offensive.                        | 28.10                   |
| 16      | 14366 May 22        | Distinct.              | Cons.           | 0.17   | Offensive.                         | Offensive.                        | 29.20                   |
| 17      | 14478 June 17       | Decided.               | Slight.         | 0.23   | Decidedly disagreeable and musty.  | Decidedly disagreeable and musty. | 41.70                   |
| 18      | 14477 June 17       | Distinct.              | Slight.         | 0.10   | Decidedly disagreeable and musty.  | Decidedly disagreeable and musty. | 37.00                   |
| 19      | 14650 July 17       | Slight.                | Slight.         | 0.20   | Offensive.                         | Offensive.                        | 35.20                   |
| 20      | 14651 July 17       | Very slight.           | Cons., dark.    | 0.15   | Decidedly musty and disagreeable.  | Offensive.                        | 39.60                   |
| 21      | 14814 Aug. 11       | Distinct.              | Heavy, yellow.  | 0.33   | Offensive.                         | Offensive.                        | 27.40                   |
| 22      | 14815 Aug. 11       | Slight.                | Slight.         | 0.28   | Distinctly musty and disagreeable. | Decidedly musty and disagreeable. | 36.00                   |
| 23      | 15216 Sept. 17      | Slight.                | Slight, earthy. | 0.10   | Decidedly disagreeable.            | Decidedly musty and disagreeable. | 34.50                   |
| 24      | 15217 Sept. 17      | Decided, iron.         | Slight, rusty.  | 0.12   | Decidedly disagreeable.            | Decidedly disagreeable.           | 35.60                   |
| 25      | 15398 Oct. 16       | Distinct, milky.       | Cons.           | 0.11   | Offensive.                         | Offensive.                        | 28.00                   |
| 26      | 15399 Oct. 16       | Very slight.           | Cons.           | 0.15   | Offensive.                         | Offensive.                        | 27.30                   |
| 27      | 15552 Nov. 14       | Very slight, milky.    | Very slight.    | 0.10   | Distinctly vinous.                 | Distinctly musty.                 | 24.70                   |
| 28      | 15553 Nov. 14       | Slight.                | Slight.         | 0.05   | Faintly musty.                     | Distinctly musty.                 | 29.60                   |
| 29      | 15728 Dec. 11       | Slight, milky.         | Very slight.    | 0.18   | Faintly musty.                     | Distinctly musty.                 | 21.00                   |
| 30      | 15729 Dec. 11       | Very slight.           | Slight, rusty.  | 0.05   | Distinctly musty.                  | Distinctly musty.                 | 23.70                   |
| 31      | 15812 Dec. 26       | Very slight.           | Very slight.    | 0.05   | Faintly musty.                     | Decidedly musty.                  | 23.60                   |
| 32      | 15813 Dec. 26       | Slight.                | Slight.         | 0.05   | Distinctly unpleasant and musty.   | Distinctly offensive.             | 24.30                   |
| 33      | Av. ....            | .....                  | .....           | 0.15   | .....                              | .....                             | 29.70                   |

The samples were collected from the under-drains, generally from those beneath

*Under-drains of the Marlborough Filter-beds — Concluded.*

[Parts per 100,000.]

| AMMONIA. |                  | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. | Iron. |    |
|----------|------------------|-----------|-------------|-----------|------------------|-----------|-------|----|
| Frec.    | Albu-<br>minoid. |           | Nitrates.   | Nitrites. |                  |           |       |    |
| 0.8480   | .0390            | 4.84      | 0.8200      | .0010     | .3357            | 7.4       | .0060 | 1  |
| 0.4980   | .0250            | 5.16      | 0.9600      | .0010     | .2370            | 7.1       | .0140 | 2  |
| 0.6720   | .0170            | 4.80      | 0.8000      | .0070     | .2828            | 7.1       | .1200 | 3  |
| 0.4000   | .0220            | 4.80      | 1.1000      | .0060     | .2409            | 9.7       | .0280 | 4  |
| 0.4240   | .0200            | 5.65      | 1.0500      | .0050     | .1638            | 7.9       | .0630 | 5  |
| 0.4800   | .0180            | 5.45      | 1.2000      | .0100     | .2964            | 8.3       | .0340 | 6  |
| 0.8800   | .0340            | 5.75      | 1.7000      | .0120     | .4068            | 8.1       | .0750 | 7  |
| 1.5360   | .0720            | 6.05      | 0.2650      | .0180     | .7070            | 8.1       | .2050 | 8  |
| 0.6400   | .0380            | 3.80      | 0.2500      | .0120     | .3673            | 6.0       | .0950 | 9  |
| 0.7680   | .0300            | 4.00      | 0.2150      | .0080     | .3476            | 5.7       | .0540 | 10 |
| 0.6720   | .0460            | 4.00      | 0.2500      | .0180     | .3157            | 5.6       | .0400 | 11 |
| 0.8000   | .0320            | 4.10      | 0.1800      | .0270     | .4004            | 6.4       | .1300 | 12 |
| 0.3440   | .0200            | 4.55      | 1.4000      | .0080     | .2194            | 8.9       | .0680 | 13 |
| 0.1680   | .0160            | 3.80      | 1.2000      | .0030     | .2194            | 7.9       | .0320 | 14 |
| 0.2880   | .0220            | 5.90      | 0.4500      | .0040     | .3534            | 7.4       | .0450 | 15 |
| 0.6200   | .0380            | 6.00      | 0.6800      | .0450     | .4218            | 7.7       | .0800 | 16 |
| 2.8160   | .0540            | 7.20      | 1.1000      | .0220     | .5008            | 11.0      | .3050 | 17 |
| 0.5040   | .0320            | 6.20      | 0.9300      | .0150     | .3724            | 10.6      | .2300 | 18 |
| 0.9440   | .0420            | 7.65      | 1.6500      | .0180     | .2400            | 10.0      | .0650 | 19 |
| 0.5600   | .0220            | 7.30      | 1.2800      | .0060     | .2512            | 9.9       | .0780 | 20 |
| 0.9250   | .0720            | 7.00      | 0.1800      | .0060     | .9360            | 6.3       | .2800 | 21 |
| 0.5600   | .0240            | 6.80      | 0.8000      | .0070     | .4446            | 9.0       | .0670 | 22 |
| 0.6240   | .0240            | 7.10      | 1.2000      | .0140     | .3633            | 7.0       | .2800 | 23 |
| 0.4800   | .0380            | 6.60      | 1.1000      | .0500     | .5382            | 7.3       | .1050 | 24 |
| 0.7360   | .0340            | 5.20      | 0.7200      | .0080     | .3666            | 6.4       | .1550 | 25 |
| 0.3040   | .0340            | 4.70      | 1.2000      | .0080     | .2668            | 6.0       | .0500 | 26 |
| 0.3680   | .0120            | 4.80      | 0.8000      | .0022     | .2184            | 6.7       | .0300 | 27 |
| 0.2640   | .0090            | 5.20      | 1.3000      | .0024     | .1833            | 8.1       | .0080 | 28 |
| 0.2400   | .0140            | 3.60      | 0.6000      | .0050     | .1560            | 7.1       | .0100 | 29 |
| 0.4160   | .0130            | 3.89      | 0.9800      | .0020     | .1638            | 6.7       | .0650 | 30 |
| 0.2400   | .0170            | 4.06      | 0.5300      | .0070     | .1540            | 6.3       | .0070 | 31 |
| 0.3200   | .0140            | 3.84      | 0.6000      | .0030     | .1848            | 6.6       | .0250 | 32 |
| 0.6427   | .0299            | 5.51      | 0.9056      | .0120     | .3444            | 7.8       | .0987 | 33 |

be beds to which sewage was being applied at the time the sample was collected.



*Chemical Examination of Water from the Brook into which the*

[Parts per 100,000.]

|    | Number. | Date of Collection. | APPEARANCE.    |                |        | ODOR.                              |                                 |
|----|---------|---------------------|----------------|----------------|--------|------------------------------------|---------------------------------|
|    |         |                     | Turbidity.     | Sediment.      | Color. | Cold.                              | Hot.                            |
|    |         | <b>1894.</b>        |                |                |        |                                    |                                 |
| 1  | 12192   | May 9               | Very slight.   | Slight, brown. | .55    | Decidedly musty and disagreeable.  | Distinctly musty.               |
| 2  | 12723   | Aug. 9              | Slight.        | Slight.        | .25    | Distinctly vegetable and musty.    | Distinctly vegetable and musty. |
| 3  | 12949   | Sept. 12            | Slight.        | Cons.          | .12    | Faintly disagreeable.              | Distinctly musty.               |
| 4  | 13319   | Nov. 14             | Slight.        | Cons.          | .30    | Faintly musty.                     | Decidedly musty.                |
| 5  | Av.     | .....               | .....          | .....          | .31    | .....                              | .....                           |
|    |         | <b>1895.</b>        |                |                |        |                                    |                                 |
| 6  | 14478   | June 17             | Slight.        | Cons.          | .20    | Distinctly disagreeable and musty. | Distinctly musty.               |
| 7  | 14662   | July 17             | Very slight.   | Cons.          | .23    | Decidedly musty and disagreeable.  | Faintly vegetable and musty.    |
| 8  | 14816   | Aug. 11             | Slight.        | Slight.        | .18    | Faintly vegetable and musty.       | Distinctly vegetable and musty. |
| 9  | 15218   | Sept. 17            | Slight, rusty. | Cons., rusty.  | .10    | Faintly musty.                     | Distinctly musty.               |
| 10 | Av.     | .....               | .....          | .....          | .19    | .....                              | .....                           |

Iron, .0270. — The samples were collected from the brook, at the road crossing below

## SEWAGE DISPOSAL AT MEDFIELD.

A system of sewage disposal by intermittent filtration was introduced at Medfield in 1886, and was described in the nineteenth annual report of the Board for the year 1887. Up to the end of 1895 connections had been made with 1 hotel, 3 houses and a large straw factory, in which, at times, as many as 900 operatives are employed. The original area of the beds was about 1 acre. The material is mostly coarse gravel. As the level of the ground water is about 10 feet below the surface of the filter, there are no underdrains. There are 4 beds, the surfaces of which are somewhat uneven, each of which, as a general rule, takes the sewage in turn for two days. It was found that there was considerable loam a

*Effluent from the Marlborough Sewage Filter-beds is discharged.*

[Parts per 100,000.]

| RESIDUE ON<br>EVAPORATION. |                      | AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |           | Oxygen Consumed. | Hardness. |    |
|----------------------------|----------------------|----------|-------------|------------|------------|-----------|-------------|-----------|------------------|-----------|----|
| Total.                     | Loss on<br>Ignition. | Free.    | ALBUMINOID. |            |            |           | Nitrates.   | Nitrites. |                  |           |    |
|                            |                      |          | Total.      | Dissolved. | Suspended. |           |             |           |                  |           |    |
| 17.50                      | 7.50                 | .0880    | .0250       | .0190      | .0060      | 2.79      | 0.4400      | .0120     | .6380            | 4.3       | 1  |
| 27.85                      | 10.10                | .0900    | .0330       | .0195      | .0135      | 4.70      | 1.5400      | .0280     | .3542            | 6.7       | 2  |
| 33.35                      | 13.35                | .3200    | .0210       | .0130      | .0080      | 5.44      | 1.3750      | .0470     | .8388            | 6.4       | 3  |
| 24.80                      | 8.70                 | .2280    | .0250       | .0210      | .0040      | 4.26      | 0.9300      | .0140     | .4485            | 4.9       | 4  |
| 25.88                      | 9.91                 | .1815    | .0260       | .0181      | .0079      | 4.30      | 1.0712      | .0253     | .4449            | 5.6       | 5  |
| 26.40                      | 8.90                 | .4000    | .0330       | .0200      | .0130      | 4.40      | 0.5000      | .0160     | .3393            | 6.4       | 6  |
| 27.20                      | 10.90                | .4320    | .0240       | .0160      | .0080      | 5.20      | 0.9000      | .0380     | .4275            | 6.9       | 7  |
| 28.20                      | 8.50                 | .2240    | .0180       | .0140      | .0040      | 5.50      | 0.6500      | .1000     | .5070            | 6.3       | 8  |
| 23.40                      | 9.30                 | .0960    | .0180       | .0150      | .0030      | 5.60      | 1.1000      | .0300     | .2948            | 5.7       | 9  |
| 27.55                      | 9.40                 | .2880    | .0232       | .0162      | .0070      | 5.17      | 0.7875      | .0710     | .3921            | 6.3       | 10 |

the filter-beds and below where the effluent from the filter-beds enters the stream.

short distance below the surface of a portion of the beds, which eventually became clogged. In the summer of 1893 this loam was removed and replaced with coarse gravel, and the area of the filter increased about one-third. Several times during the warm weather the surfaces were harrowed, but they have not been ridged for service in the winter.

No trouble has arisen from odors. In the following tables will be found analyses of the sewage, and of the effluent taken from a spring a short distance below the filter. The effluent is of excellent quality, and no marked deterioration is shown by the analyses when compared with those made in 1887, after the works had been in operation for a comparatively short time.

*Chemical Examination of*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.     |               |         | RESIDUE ON EVAPORATION. |            |            |                   |            |            |
|---------|---------------------|-----------------|---------------|---------|-------------------------|------------|------------|-------------------|------------|------------|
|         |                     | Turbidity.      | Sediment.     | Color.* | TOTAL RESIDUE.          |            |            | LOSS ON IGNITION. |            |            |
|         |                     |                 |               |         | Total.                  | Dissolved. | Suspended. | Total.            | Dissolved. | Suspended. |
| 1       | 11761 Feb. 14       | Thick, green.   | Heavy, dark.  | -       | 41.20                   | 33.40      | 7.80       | 21.60             | 14.80      | 6.80       |
| 2       | 12360 June 12       | Thick, black.   | Cons., black. | -       | 26.80                   | 22.80      | 4.00       | 13.20             | 10.00      | 3.20       |
| 3       | 12701 Aug. 9        | Thick.          | Cons., dark.  | -       | 59.40                   | 47.40      | 12.00      | 37.20             | 28.40      | 8.80       |
| 4       | 13210 Oct. 24       | Thick, colored. | Heavy, black. | -       | 80.20                   | 63.40      | 16.80      | 36.00             | 26.80      | 9.20       |
| 5       | 13477 Dec. 12       | Decided.        | Heavy.        | 8.50    | 30.60                   | 27.80      | 2.80       | 14.20             | 12.40      | 1.80       |
| 6       | Av. ....            |                 |               | -       | 47.64                   | 38.96      | 8.68       | 24.44             | 18.48      | 5.96       |
| 7       | 13820 Feb. 13       | Black, opaque.  | Heavy.        | -       | 112.80                  | 103.40     | 9.40       | 43.20             | 34.60      | 8.60       |
| 8       | 14124 April 10      | Opaque.         | Opaque.       | -       | 98.00                   | 86.40      | 12.20      | 44.40             | 34.40      | 10.00      |
| 9       | 14525 June 21       | Decided.        | Heavy.        | 6.00    | 37.80                   | 32.80      | 5.00       | 16.80             | 12.60      | 4.20       |
| 10      | 14846 Aug. 15       | Opaque.         | Considerable. | -       | 46.40                   | 41.60      | 4.80       | 29.40             | 23.80      | 5.60       |
| 11      | 15395 Oct. 17       | Decided.        | Considerable. | 0.70    | 20.20                   | 18.50      | 1.70       | 5.00              | 4.10       | 0.90       |
| 12      | 15725 Dec. 11       | Opaque.         | Considerable. | -       | 31.00                   | 25.60      | 5.40       | 13.00             | 8.80       | 4.20       |
| 13      | Av. ....            |                 |               | -       | 57.80                   | 51.38      | 6.42       | 25.30             | 19.72      | 5.58       |

\* The color of many of these samples was affected by the presence of spent dye liquors in the sewage.

*Chemical Examination of Water from a Spring below*

[Parts per 100,000.]

| Number. | Date of Collection. | APPEARANCE.         |                 |        | ODOR.                          |                       | Residue on Evaporation. |
|---------|---------------------|---------------------|-----------------|--------|--------------------------------|-----------------------|-------------------------|
|         |                     | Turbidity.          | Sediment.       | Color. | Cold.                          | Hot.                  |                         |
| 1894.   |                     |                     |                 |        |                                |                       |                         |
| 1       | 11669 Jan. 22       | None.               | Slight.         | 0.00   | None.                          | Very faint or none.   | 6.95                    |
| 2       | 11762 Feb. 14       | Very slight.        | Slight.         | 0.02   | Very faint or none.            | Very faint or none.   | 9.6                     |
| 3       | 12361 June 12       | None.               | Slight.         | 0.04   | Very faint or none.            | Distinct, peculiar.   | 11.20                   |
| 4       | 12702 Aug. 9        | Very slight.        | Slight, earthy. | 0.05   | None                           | Very faint or none    | 10.50                   |
| 5       | 13211 Oct. 24       | None.               | Very slight.    | 0.04   | Very faint or none.            | Very faintly musty.   | 22.80                   |
| 6       | 13478 Dec. 12       | Very slight.        | Slight.         | 0.65   | Very faint or none.            | Faintly vegetable     | 16.40                   |
| 7       | Av.                 |                     |                 | 0.13   |                                |                       | 12.96                   |
| 1895.   |                     |                     |                 |        |                                |                       |                         |
| 8       | 13821 Feb. 13       | Slight.             | Cons.           | 0.03   | None.                          | None.                 | 4.70                    |
| 9       | 14125 April 10      | Very slight, milky. | Cons., earthy.  | 0.75   | Faintly unpleasant.            | Faintly vegetable.    | 12.00                   |
| 10      | 14526 June 21       | Very slight.        | Cons.           | 0.23   | Faintly vegetable, unpleasant. | Faintly vegetable     | 9.30                    |
| 11      | 14847 Aug. 15       | Slight.             | Cons.           | 0.12   | Very faint or none.            | Faintly vegetable.    | 9.40                    |
| 12      | 15396 Oct. 17       | Slight.             | Cons.           | 1.10   | Distinctly vegetable.          | Distinctly vegetable. | 40.10                   |
| 13      | 15726 Dec. 11       | Slight.             | Slight.         | 0.07   | Very faint or none.            | Very faint or none.   | 4.70                    |
| 14      | Av.                 |                     |                 | 0.38   |                                |                       | 13.47                   |

The samples were collected from the spring, which is located north of the filter-beds and a little to the direction of this spring.

*Sewage from Medfield.*

[Parts per 100,000.]

| AMMONIA. |             |            |            | Chlorine. | NITROGEN AS |          | OXYGEN CONSUMED. |           | IRON.      |           | Hardness. |    |
|----------|-------------|------------|------------|-----------|-------------|----------|------------------|-----------|------------|-----------|-----------|----|
| Free.    | ALBUMINOID. |            |            |           | Nitrate.    | Nitrite. | Undiluted.       | Filtered. | Undiluted. | Filtered. |           |    |
|          | Total.      | Dissolved. | Suspended. |           |             |          |                  |           |            |           |           |    |
| 1.2800   | 0.9260      | 0.8260     | .1000      | 2.40      | .0050       | .0100    | 4.7200           | 3.8800    | 0.0400     | .0200     | 2.9       | 1  |
| 0.3600   | 0.2300      | 0.1300     | .1000      | 1.27      | -           | .0010    | 4.9434           | 3.9116    | -          | -         | 2.6       | 2  |
| 10.8800  | 1.8000      | 1.5000     | .3000      | 2.38      | .0000       | .0000    | -                | 6.1600    | -          | -         | 6.5       | 3  |
| 0.2640   | 0.3660      | 0.2660     | .1000      | 2.72      | .0000       | .0000    | 18.9830          | 10.8625   | 1.8000     | .0660     | 6.7       | 4  |
| 0.2960   | 0.2800      | 0.2040     | .0860      | 1.80      | .0050       | .0040    | 5.0050           | 3.9270    | 0.0520     | .0400     | 4.6       | 5  |
| 2.6160   | 0.7164      | 0.5862     | .1312      | 2.11      | .0025       | .0030    | 7.1629           | 5.7482    | 0.4640     | .0447     | 4.7       | 6  |
| 2.8800   | 1.6000      | 1.5200     | .0800      | 4.15      | .0000       | .0000    | 10.0800          | 6.9200    | 0.1000     | .0640     | 38.0      | 7  |
| 0.9920   | 0.9700      | 0.7060     | .2640      | 7.10      | .0000       | .0050    | 18.5570          | 16.4780   | 0.5500     | .3000     | 10.0      | 8  |
| 0.9960   | 0.4240      | 0.2720     | .1520      | 3.50      | .0000       | .0000    | 5.0050           | 4.1965    | 0.1300     | .0900     | 3.2       | 9  |
| 1.7280   | 0.4740      | 0.2980     | .1760      | 2.70      | .0000       | .0000    | 28.5480          | 22.6200   | 0.3000     | .3000     | 4.0       | 10 |
| 0.2320   | 0.0880      | 0.0500     | .0380      | 2.30      | .0250       | .0500    | 1.5600           | 1.0920    | 0.0330     | .0200     | 6.3       | 11 |
| 1.4400   | 0.3100      | 0.2900     | .0200      | 2.50      | .0080       | .0000    | 6.0060           | 3.9936    | -          | -         | 4.3       | 12 |
| 1.8613   | 0.6443      | 0.5227     | .1216      | 3.76      | .0056       | .0092    | 11.6260          | 9.2167    | 0.2226     | .1548     | 10.0      | 13 |

and in many cases could not be determined satisfactorily.

Odor, offensive. — The samples were collected as the sewage flowed upon the filter-beds.

*the Filtration Area of the Medfield Sewerage System.*

[Parts per 100,000.]

| AMMONIA. |             | Chlorine. | NITROGEN AS |          | Oxygen Consumed. | Hardness. | Iron. |    |
|----------|-------------|-----------|-------------|----------|------------------|-----------|-------|----|
| Free.    | Albuminoid. |           | Nitrate.    | Nitrite. |                  |           |       |    |
| .0002    | .0034       | 1.86      | 0.2000      | .0000    | 0.1106           | 3.0       | .0025 | 1  |
| .0004    | .0056       | 1.19      | 0.1500      | .0000    | 0.1200           | 2.7       | .0100 | 2  |
| .0008    | .0042       | 0.95      | 0.1250      | .0000    | 0.0385           | 2.9       | -     | 3  |
| .0006    | .0070       | 0.98      | 0.3000      | .0002    | 0.1101           | 3.6       | .0010 | 4  |
| .0010    | .0120       | 1.22      | 0.9000      | .0001    | 0.2054           | 6.7       | .0050 | 5  |
| .0132    | .0284       | 1.82      | 0.2400      | .0000    | 0.5698           | 3.6       | .0030 | 6  |
| .0027    | .0101       | 1.25      | 0.3192      | .0001    | 0.1924           | 3.8       | .0043 | 7  |
| .0014    | .0042       | 0.40      | 0.1100      | .0001    | 0.1344           | 1.8       | .0010 | 8  |
| .0066    | .0160       | 1.15      | 0.3000      | .0006    | 0.6406           | 3.5       | .0030 | 9  |
| .0004    | .0100       | 0.76      | 0.1000      | .0002    | 0.4081           | 2.3       | .0120 | 10 |
| .0058    | .0130       | 0.97      | 0.1100      | .0020    | 0.2106           | 4.2       | .0250 | 11 |
| .0550    | .0910       | 6.00      | 1.0500      | .0008    | 1.3806           | 12.9      | .0090 | 12 |
| .0000    | .0030       | 0.51      | 0.1000      | .0003    | 0.1108           | 1.6       | .0050 | 13 |
| .0115    | .0229       | 1.63      | 0.2950      | .0007    | 0.4808           | 4.4       | .0092 | 14 |

over 200 feet from the edge of the nearest bed. The ground where the filter-beds are located slopes in



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# FOOD AND DRUG INSPECTION.

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## FOOD AND DRUG INSPECTION.

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The following report comprises the operations of the Board under the provisions of the food and drug acts for the year ending Sept. 30, 1895.

The force employed by the Board during the year consisted of the following persons :—

|                                       |                           |
|---------------------------------------|---------------------------|
| Dr. CHARLES P. WORCESTER, . . . . .   | <i>Analyst.</i>           |
| Prof. CHARLES A. GOESSMANN, . . . . . | <i>Analyst.</i>           |
| Mr. ALBERT E. LEACH, . . . . .        | <i>Assistant Analyst.</i> |
| JOHN H. TERRY, . . . . .              | <i>Inspector.</i>         |
| JOHN F. McCAFFREY, . . . . .          | <i>Inspector.</i>         |
| HORACE F. DAVIS, . . . . .            | <i>Inspector.</i>         |
| THOMAS O. ALLEN, . . . . .            | <i>Inspector.</i>         |

In addition to the force employed in 1894, Mr. Thomas O. Allen was appointed by the Board in 1895, to act in the towns in the neighborhood of Lowell.

The whole number of samples of food and drugs (including milk) examined during the year was 7,309, or 435 more than the number examined in the year ending Sept. 30, 1894, and 1,405 more than the average annual number examined in the ten years from Sept. 30, 1885, to Sept 30, 1895.

The whole number examined since the beginning of operations in this department in 1883 was 67,756.

The following summary embraces the work done during the year :—

|                                                                |       |
|----------------------------------------------------------------|-------|
| Number of samples of milk examined, . . . . .                  | 3,794 |
| Number of samples above standard, . . . . .                    | 1,905 |
| Number of samples below standard, . . . . .                    | 1,889 |
| Percentage of adulteration or deficiency, . . . . .            | 49.8  |
| Number of samples of other kinds of food (not milk), . . . . . | 2,971 |
| Number of samples above standard, . . . . .                    | 2,379 |
| Number of samples below standard, . . . . .                    | 592   |
| Percentage of adulteration, . . . . .                          | 19.9  |



|                                                                      |      |
|----------------------------------------------------------------------|------|
| Number of samples of drugs examined, . . . . .                       | 544  |
| Number of samples of good quality, . . . . .                         | 212  |
| Number of samples adulterated, as defined by the statutes, . . . . . | 332  |
| Percentage of adulteration, . . . . .                                | 61.0 |

|                                                               |       |
|---------------------------------------------------------------|-------|
| Total number of samples of food and drugs examined, . . . . . | 7,309 |
| Total number found to be of good quality, . . . . .           | 4,496 |
| Total number not conforming to the statutes, . . . . .        | 2,813 |
| Percentage of adulteration, . . . . .                         | 38.5  |

Attention has already been called, in previous reports, to the fact that the percentages given in the foregoing summary do not represent, in any degree, the actual ratio of adulteration existing in food products and in drugs, for several reasons: chiefly on account of the fact that the experience of the Board enables it, first, to exercise a careful selection of such articles, mainly, as are liable to adulteration; secondly, to obtain such articles in those seasons of the year when their adulteration is most common; and third, to pay special attention to new forms of adulteration which are constantly appearing as fast as the fraud and ingenuity of the professional adulterator presents them to the public.

Legislation itself has an effect upon the ratio of samples found to be adulterated. For example, in 1885, 273 samples of vinegar were examined and 81 per cent. were found to be below the standard. Had these samples been examined in the following year, only 61 per cent. would have fallen below the standard, since the standard of acetic acid in vinegar was reduced by the law of 1885 from 5 per cent. to  $4\frac{1}{2}$  per cent. and about 20 per cent. of the number of samples were found to range between  $4\frac{1}{2}$  and 5 per cent.

The following tables present a summary of the work done during the entire period from the beginning of operations under the food and drug acts in 1883 to the close of the year ending Sept. 30, 1895:—

## STATISTICAL SUMMARY.

## FOOD AND DRUG INSPECTION (1888-95).

| SUMMARY.                                                                  | YEARS.     |            |            |            |            |            |             |            |            |             |
|---------------------------------------------------------------------------|------------|------------|------------|------------|------------|------------|-------------|------------|------------|-------------|
|                                                                           | 1883.      | 1884.      | 1885.      | 1886.      | 1887.      | 1888.      | 1889.       | 1890.      | 1891.      | 1892.       |
| Number of samples of milk examined, . . . . .                             | 218        | 1,123      | 2,219      | 2,085      | 3,081      | 2,825      | 3,219       | 2,825      | 3,081      | 3,219       |
| Number of samples above standard, . . . . .                               | 35         | 347        | 1,297      | 1,323      | 1,900      | 1,705      | 1,971       | 1,705      | 1,900      | 1,971       |
| Number of samples below standard, . . . . .                               | 183        | 776        | 922        | 762        | 1,181      | 1,120      | 1,248       | 1,120      | 1,181      | 1,248       |
| Percentage of adulteration, . . . . .                                     | 83.9       | 69.1       | 41.7       | 36.5       | 38.3       | 39.6       | 38.7        | 39.6       | 38.3       | 38.7        |
| Number of samples of other kinds of food (not milk), . . . . .            | 477        | 839        | 1,552      | 1,353      | 1,789      | 2,079      | 1,635       | 2,079      | 1,789      | 1,635       |
| Number of samples of good quality, . . . . .                              | 328        | 432        | 883        | 863        | 1,263      | 1,080      | 1,242       | 1,080      | 1,263      | 1,242       |
| Number of samples adulterated, as defined by the statutes, . . . . .      | 149        | 407        | 669        | 490        | 526        | 999        | 393         | 999        | 526        | 393         |
| Percentage of adulteration, . . . . .                                     | 31.2       | 48.5       | 43.1       | 36.2       | 29.4       | 19.2       | 24.0        | 19.2       | 29.4       | 24.0        |
| Number of samples of drugs examined, . . . . .                            | 603        | 662        | 1,007      | 888        | 550        | 862        | 600         | 862        | 550        | 600         |
| Number of samples of good quality, . . . . .                              | 357        | 431        | 571        | 463        | 400        | 634        | 503         | 634        | 400        | 503         |
| Number of samples adulterated, as defined by the statutes, . . . . .      | 246        | 231        | 436        | 425        | 150        | 228        | 97          | 228        | 150        | 97          |
| Percentage of adulteration, . . . . .                                     | 40.8       | 36.8       | 43.3       | 47.8       | 27.3       | 26.4       | 16.2        | 26.4       | 27.3       | 16.2        |
| Total examinations of food and drugs, . . . . .                           | 1,298      | 2,644      | 4,778      | 4,326      | 5,420      | 5,766      | 5,454       | 5,766      | 5,420      | 5,454       |
| Total examinations of good quality, . . . . .                             | 720        | 1,210      | 2,751      | 2,619      | 3,563      | 4,019      | 3,716       | 4,019      | 3,563      | 3,716       |
| Total examinations not conforming to the statutes, . . . . .              | 578        | 1,434      | 2,027      | 1,707      | 1,857      | 1,747      | 1,738       | 1,747      | 1,857      | 1,738       |
| Percentage of adulteration, . . . . .                                     | 44.5       | 54.2       | 42.7       | 39.7       | 34.3       | 30.3       | 31.9        | 30.3       | 34.3       | 31.9        |
| Expense of collection, examination and prosecution, . . . . .             | \$2,931 56 | \$5,529 60 | \$8,557 43 | \$8,025 34 | \$8,803 62 | \$9,915 41 | \$10,356 28 | \$9,915 41 | \$8,803 62 | \$10,356 28 |
| Expense of collection, examination and prosecution, per sample, . . . . . | 2 26       | 2 09       | 1 79       | 1 85       | 1 2        | 1 64       | 1 89        | 1 64       | 1 2        | 1 89        |

FOOD AND DRUG INSPECTION (1883-95) — *Concluded.*

| SUMMARY.                                                                  | YEARS.      |             |             |             |             |             | TOTAL.       |
|---------------------------------------------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|
|                                                                           | 1890.       | 1891.       | 1892.       | 1893.       | 1894.       | 1895.       |              |
| Number of samples of milk examined, . . . . .                             | 3,256       | 2,726       | 3,271       | 3,073       | 3,551       | 3,794       | 34,421       |
| Number of samples above standard, . . . . .                               | 1,858       | 1,629       | 1,757       | 1,545       | 1,794       | 1,905       | 19,066       |
| Number of samples below standard, . . . . .                               | 1,378       | 1,097       | 1,514       | 1,528       | 1,757       | 1,889       | 15,355       |
| Percentage of adulteration, . . . . .                                     | 42.6        | 40.2        | 46.3        | 49.7        | 49.5        | 49.8        | 44.6         |
| Number of samples of other kinds of food examined (not milk), . . . . .   | 2,349       | 2,144       | 2,441       | 3,009       | 2,836       | 2,971       | 25,474       |
| Number of samples of good quality, . . . . .                              | 1,913       | 1,577       | 2,042       | 2,637       | 2,566       | 2,379       | 19,805       |
| Number of samples adulterated, as defined by the statutes, . . . . .      | 436         | 567         | 399         | 372         | 270         | 592         | 5,669        |
| Percentage of adulteration, . . . . .                                     | 18.6        | 26.4        | 16.3        | 12.3        | 9.5         | 19.9        | 22.3         |
| Number of samples of drugs examined, . . . . .                            | 400         | 424         | 487         | 327         | 487         | 544         | 7,861        |
| Number of samples of good quality, . . . . .                              | 325         | 352         | 312         | 228         | 324         | 212         | 5,112        |
| Number of samples adulterated, as defined by the statutes, . . . . .      | 75          | 72          | 175         | 99          | 163         | 332         | 2,749        |
| Percentage of adulteration, . . . . .                                     | 18.7        | 17.0        | 35.9        | 30.3        | 33.5        | 61.0        | 35.0         |
| Total examinations of food and drugs, . . . . .                           | 5,985       | 5,294       | 6,190       | 6,409       | 6,874       | 7,309       | 67,756       |
| Total examinations of good quality, . . . . .                             | 4,096       | 3,558       | 4,111       | 4,410       | 4,084       | 4,406       | 43,983       |
| Total examinations not conforming to the statutes, . . . . .              | 1,889       | 1,736       | 2,088       | 1,999       | 2,190       | 2,813       | 23,773       |
| Percentage of adulteration, . . . . .                                     | 31.5        | 32.8        | 33.7        | 31.2        | 31.9        | 38.5        | 35.1         |
| Expense of collection, examination and prosecution, . . . . .             | \$10,013 04 | \$10,019 41 | \$11,180 30 | \$10,454 11 | \$10,364 64 | \$11,375 89 | \$116,526 63 |
| Expense of collection, examination and prosecution, per sample, . . . . . | 1 67        | 1 80        | 1 80        | 1 63        | 1 52        | 1 56        | 1 72         |

The removal of the office of the Board, as well as the laboratory for food and drug analysis, to the present quarters under one roof at the State House has proved to be a matter of great convenience, since it not only allows a greater amount of work to be done, but also affords better opportunity for consultation between the Board and its analysts in all difficult and doubtful cases.

### MILK.

The great importance of milk as an article of food for all classes of people, and especially for the young, the ease with which its adulteration is accomplished and the difficulty of its detection by the ordinary consumer, constituted a sufficient reason for the legal requirement that a definite and comparatively large ratio of the expense of carrying out the provisions of the law should be employed in the inspection of milk and its products.

The questions pertaining to commercial fraud in the sale of milk products (milk, butter and cheese) are sufficiently provided for by existing laws, and there appears to be a tendency at the present time towards legislation in the more important direction of the sanitary control of the milk supply. The recent acts providing for the inspection of milch cows, and the destruction of such as are found to be diseased, undoubtedly give greater security to the consumers of milk.

While this is eminently desirable, it is quite as necessary that legislation should provide for prevention of the recurrence of disease in the future by requiring the frequent inspection, by competent authority, of the places in which dairy animals are kept for the production of milk, and that special attention should be paid to their housing, their water supply, the ventilation and drainage of their stables and the quality of their food.

During the past few years the Board has been called upon frequently to investigate the causes of outbreaks of typhoid fever, and in several instances the medium of infection has been found to be the milk supply. It is needless to add that carelessness in management and want of cleanliness in some of the details of dairy work were invariably found to exist in such cases. Local boards of health will accomplish much by encouraging the establishment of *model dairies*, in which milk is produced and prepared for sale under the best possible conditions. The cost of such milk may be a little higher to the consumer, but the security which is gained will pay in the end. The game is well worth the candle.

Several points in the reports of the analysts are worthy of note. The appearance, during the year, of a comparatively new coloring matter, employed in the adulteration of milk, has led to a careful investigation of its character and composition. The substance employed is an aniline dye, and the quantity required to produce the color of a rich milk is quite small. Fortunately, the dye is easy of detection when introduced into milk, as is shown in the report of the analyst.

Attention is called to the figures showing the results of analysis in a case where the analysis of nine samples was made by three chemists, the chemist of the Board and two others to whom the samples were submitted. The greatest difference in these analyses was only  $1\frac{12}{100}$  of one per cent.

The claim is often urged by milk producers that it is impossible to produce milk which shall uniformly satisfy the requirements of the law, and instances are adduced of single animals of some particular breed which produce milk of a quality considerably below the legal standard. To the influence thus produced by the employment of breeds which furnish milk of a low standard is added the effect of using impoverished food, which tends to increase the quantity of milk at the expense of its quality.

It is, however, rare to find a herd of cows, consisting, as is usually the case, of a variety of breeds, in which the average mixture of the milk of the dairy falls below the legal standard of solids. It is not an uncommon event to find that the milk taken on the street from wagons, under the ordinary conditions of delivery, is nearly or quite as good as that which is produced at the dairies.

The following is a fair sample of a single collection of milk made in one city in the month of July, when the legal standard is 12 per cent. :—

| INSPECTOR'S NUMBER. | Total Solids. | Wagon or Shop. | INSPECTOR'S NUMBER. | Total Solids. | Wagon or Shop. |
|---------------------|---------------|----------------|---------------------|---------------|----------------|
| 8421, . . .         | 13.94         | Wagon.         | 8443, . . .         | 13.50         | Wagon.         |
| 8423, . . .         | 13.10         | Wagon.         | 8445, . . .         | 12.27         | Wagon.         |
| 8425, . . .         | 12.00         | Wagon.         | 8447, . . .         | 13.35         | Wagon.         |
| 8427, . . .         | 12.70         | Wagon.         | 8449, . . .         | 12.64         | Wagon.         |
| 8429, . . .         | 12.74         | Wagon.         | 8451, . . .         | 15.67         | Wagon.         |
| 8431, . . .         | 12.23         | Wagon.         | 8453, . . .         | 12.82         | Wagon.         |
| 8433, . . .         | 12.77         | Wagon.         | 8455, . . .         | 12.40         | Wagon.         |
| 8435, . . .         | 13.03         | Wagon.         | 8457, . . .         | 12.84         | Wagon.         |
| 8437, . . .         | 13.46         | Wagon.         | 8459, . . .         | 12.64         | Wagon.         |
| 8439, . . .         | 12.60         | Wagon.         |                     |               |                |
| 8441, . . .         | 13.00         | Wagon.         | Average, .          | 12.98         |                |

A table of analyses of different brands of condensed milk is presented in the report, showing at the first glance a fairly uniform quality in the samples examined. Close inspection, however, shows considerable differences in their composition, so far as they relate to the original nutrient constituents of the milk from which the samples were made. For example, the proteids showed a maximum of 9.83 per cent. and a minimum of 5.95 per cent., the milk sugar a maximum of 20.06 per cent. and a minimum of 7.05 per cent., and the fat a maximum of 12.3 per cent. and a minimum of 7.4 per cent.

The average constituents of the thirty-three samples were as follows:—

|                                  |       |
|----------------------------------|-------|
| Total solids, . . . . .          | 72.32 |
| Water, . . . . .                 | 27.76 |
| Milk solids, . . . . .           | 32.37 |
| Cane sugar, . . . . .            | 39.94 |
| Milk sugar, . . . . .            | 13.01 |
| Proteids, . . . . .              | 8.10  |
| Fat, . . . . .                   | 9.69  |
| Ash, . . . . .                   | 1.58  |
| Fat in original milk,* . . . . . | 4.05  |

As is quite commonly the case, the prices at which these different brands were sold afforded no indication of their comparative quality.

#### LOCAL INSPECTION.

The statutes provide that in every city there *shall* be a local inspector of milk, while in the towns the law is permissive only. As the towns increase in population, especially in the metropolitan district, the number in which milk inspectors are provided by the municipal authorities annually increases, and thus greater protection is constantly afforded against the adulteration of this important food. It is desirable that every town having a population of more than five thousand inhabitants should appoint an inspector, and give him such support in carrying out the law as the subject demands.

#### BUTTER.

The fact that more than 97 per cent. of the samples of butter obtained by the inspectors (186 out of 191 samples) proved to be genuine is a fair indication of the methods of sale of this article in open market, and of the extent of adulteration or of illegal sales,

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\* Assuming a standard of 9.3 per cent. for solids not fat.

since the inspectors in obtaining samples of butter at retail have diligently sought for places where adulteration would be most liable to exist.

#### LARD.

Special attention has been paid by the analyst to the examination of lard and to the different methods of detection of its two principal adulterants, — cotton seed oil and the fats of beef, — since the presence of adulterated lard in the cities of Massachusetts has increased quite recently to a considerable degree.

#### SPICES.

The examination of spices shows a wholesome state of the market as compared with that of 1883–84 (the beginning of operations under the food acts), when 65 per cent. of spices examined were found to be adulterated. The percentage of adulteration last year was 16.3 per cent., or about one-fourth of that which prevailed a dozen years since.

#### MAPLE SYRUP AND SUGAR.

These valuable products of the rock or sugar maple tree have been made the subjects of careful study, and some advance has been made in the matter of distinguishing the different varieties of sugar which closely resemble cane sugar in their chemical composition. The rough inspection afforded by the senses of sight, taste and smell still give important aid in the examination of these articles.

#### EGG SUBSTITUTES.

The analysis of these preparations shows how little reliance can be placed in the statements of the inventors or manufacturers of new or patent food preparations with reference to their actual nutrient value.

#### COOKING UTENSILS.

While the food and drug act of Massachusetts does not provide, as in some countries, for the inspection of the utensils in which food is prepared for use, the Board has deemed it proper to make such investigations in this direction as may be necessary for the protection of the public. Considerable agitation having arisen during the year, as shown by comments in the newspapers, in regard to the possible danger which might arise from the use of “agate,” “gran-

ite" or enamelled ware, which is largely sold for culinary purposes, the Board ordered an examination to be made. It had been charged that the enamelled coating of such utensils contained arsenic. Arsenic was found in only one instance, and in that case the quantity was inconsiderable and such only as might have been due to a slight impurity in the material used for glazing. More than half of the utensils contained antimony.

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The following figures afford a very good illustration of the advantages secured by the enactment of a well-devised food and drug statute.

In 1884, soon after the enactment of the law and before an adequate appropriation had been provided for its enforcement, an examination of spices and cream of tartar, and other articles of food, as sold in open market in Massachusetts gave the following results:—

Samples of spices collected in 1884, 431. Number adulterated, 216, or 50.1 per cent.

Samples of spices collected in July, 1896, 78. Number adulterated, 2, or 2.6 per cent.

Samples of cream of tartar collected in 1884, 232. Number adulterated, 77, or 33.2 per cent.

Samples of cream of tartar collected in July, 1896, 25, of which 1 was adulterated, or 4 per cent.

Out of 123 samples of butter, cheese, tea, coffee and confectionery collected in 1884, 15, or 12.2 per cent., were adulterated.

Out of 82 samples of the same articles collected under similar conditions in July, 1896, all proved to be genuine.

### DRUGS.

The principal drugs found to be adulterated by the analyst are as follows:—

Ether, distilled water, extract of licorice, compound spirits of ether, spirits of nitrous ether (all below standard and more than half showing less than 50 per cent. of the required strength), the pharmacopœial wines and liquor, tincture of opium, official soap and mercuric ointment. Much greater care is necessary in the preparation of distilled water. Its use for preparing eye-lotions, for the solution of nitrate of silver and other salts, and many other purposes requiring pure water, calls for a carefully made article, and yet it was quite commonly found on analysis to be nothing but



the tap-water of the city or town supply, and in one instance it contained more impurities than ordinary sewage. It is needless to say that a conviction and fine followed close upon this sale.

### NOTICES.

The following are the names of the cities and towns to which warning notices were sent during the year, stating that the parties to whom they were sent were found to be retailing food and drugs which were below the required standard of purity.

This form of notice was adopted for the purpose of giving information to retailers, where there is presumptive evidence that they are not aware of the fact that the articles in question are below the standard quality required by the statutes. Such notices are not required by the statutes, and failure to receive them does not exempt the retailer from liability to complaint at court.

#### *Cities and Towns to which Notices were sent on Account of Adulterated Milk.*

|                       |    |                         |     |
|-----------------------|----|-------------------------|-----|
| Barre, . . . . .      | 2  | Natick, . . . . .       | 1   |
| Bedford, . . . . .    | 1  | Newton, . . . . .       | 4   |
| Berlin, . . . . .     | 2  | Onset Bay, . . . . .    | 1   |
| Boston, . . . . .     | 2  | Peabody, . . . . .      | 1   |
| Brockton, . . . . .   | 3  | Provincetown, . . . . . | 2   |
| Brookline, . . . . .  | 1  | Quincy, . . . . .       | 3   |
| Cambridge, . . . . .  | 25 | Revere, . . . . .       | 4   |
| Chelsea, . . . . .    | 14 | Rochester, . . . . .    | 1   |
| Clinton, . . . . .    | 1  | Salem, . . . . .        | 4   |
| Dedham, . . . . .     | 6  | Somerville, . . . . .   | 18  |
| Deerfield, . . . . .  | 1  | Stoneham, . . . . .     | 4   |
| Dover, . . . . .      | 1  | Stoughton, . . . . .    | 2   |
| Everett, . . . . .    | 16 | Sudbury, . . . . .      | 3   |
| Fall River, . . . . . | 8  | Waltham, . . . . .      | 2   |
| Gardner, . . . . .    | 2  | Ware, . . . . .         | 1   |
| Gloucester, . . . . . | 8  | Wareham, . . . . .      | 1   |
| Hardwick, . . . . .   | 3  | Watertown, . . . . .    | 5   |
| Haverhill, . . . . .  | 2  | West Newton, . . . . .  | 6   |
| Holliston, . . . . .  | 1  | Weston, . . . . .       | 1   |
| Holyoke, . . . . .    | 3  | Weymouth, . . . . .     | 1   |
| Hull, . . . . .       | 2  | Winchester, . . . . .   | 5   |
| Hyde Park, . . . . .  | 5  | Winthrop, . . . . .     | 2   |
| Lawrence, . . . . .   | 6  | Woburn, . . . . .       | 18  |
| Lexington, . . . . .  | 1  | Worcester, . . . . .    | 3   |
| Malden, . . . . .     | 12 |                         |     |
| Medford, . . . . .    | 6  |                         |     |
| Nantucket, . . . . .  | 2  |                         |     |
|                       |    | Total, . . . . .        | 229 |

*ies and Towns to which Notices were sent on Account of Adullerated Articles of Food other than Milk.*

|                     |    |                         |    |
|---------------------|----|-------------------------|----|
| ngton, . . . . .    | 2  | Pittsfield, . . . . .   | 1  |
| eborough, . . . . . | 2  | Plymouth, . . . . .     | 2  |
| ckstone, . . . . .  | 10 | Provincetown, . . . . . | 2  |
| ton, . . . . .      | 34 | Salem, . . . . .        | 1  |
| ckton, . . . . .    | 1  | Spencer, . . . . .      | 2  |
| bridge, . . . . .   | 4  | Springfield, . . . . .  | 1  |
| River, . . . . .    | 7  | Stoneham, . . . . .     | 1  |
| hburg, . . . . .    | 2  | Taunton, . . . . .      | 1  |
| dner, . . . . .     | 1  | Ware, . . . . .         | 4  |
| ucester, . . . . .  | 1  | Watertown, . . . . .    | 2  |
| yoke, . . . . .     | 3  | Westtown, . . . . .     | 2  |
| rence, . . . . .    | 2  | Woburn, . . . . .       | 2  |
| rell, . . . . .     | 6  |                         |    |
| n, . . . . .        | 1  | Total, . . . . .        | 98 |
| et, . . . . .       | 1  |                         |    |

*ities and Towns to which Notices were sent on Account of Adullerated Drugs.*

|                      |    |                         |    |
|----------------------|----|-------------------------|----|
| ams, . . . . .       | 1  | North Adams, . . . . .  | 4  |
| ington, . . . . .    | 2  | Northampton, . . . . .  | 1  |
| leborough, . . . . . | 1  | Peabody, . . . . .      | 1  |
| ckstone, . . . . .   | 1  | Provincetown, . . . . . | 1  |
| ton, . . . . .       | 16 | Salem, . . . . .        | 2  |
| nbridge, . . . . .   | 7  | Spencer, . . . . .      | 1  |
| elsea, . . . . .     | 3  | Springfield, . . . . .  | 5  |
| l River, . . . . .   | 4  | Stoneham, . . . . .     | 1  |
| hburg, . . . . .     | 1  | Taunton, . . . . .      | 1  |
| dner, . . . . .      | 2  | Waltham, . . . . .      | 4  |
| ucester, . . . . .   | 3  | Westfield, . . . . .    | 2  |
| yoke, . . . . .      | 8  | West Medway, . . . . .  | 1  |
| vell, . . . . .      | 1  | West Newton, . . . . .  | 1  |
| lden, . . . . .      | 4  | Winchester, . . . . .   | 2  |
| rblehead, . . . . .  | 1  |                         |    |
| lrose, . . . . .     | 1  | Total, . . . . .        | 84 |
| w Bedford, . . . . . | 1  |                         |    |

## PROSECUTIONS.

In the reports of the last three years a condensed summary was presented, showing the number of prosecutions conducted in each year since the beginning of work under the food and drugs acts. The following table presents the same figures, with the addition of those for the year ending Sept. 30, 1895: —

*Number of Complaints entered in Court.*

| YEAR.        | Food<br>not including<br>Milk. | Drugs. | Milk. | Total. | Convictions. | Fines<br>Imposed. |
|--------------|--------------------------------|--------|-------|--------|--------------|-------------------|
| 1883, . . .  | —                              | 5      | 4     | 9      | 8            | —†                |
| 1884, . . .  | 2                              | 1      | 45    | 48     | 44           | —†                |
| 1885,* . . . | 50                             | 1      | 68    | 119    | 103          | —†                |
| 1886,† . . . | 10                             | —      | 10    | 20     | 19           | —†                |
| 1887, . . .  | 30                             | —      | 34    | 64     | 60           | —†                |
| 1888, . . .  | 22                             | —      | 43    | 65     | 61           | \$2,042 00        |
| 1889, . . .  | 74                             | —      | 66    | 140    | 124          | 3,889 00          |
| 1890, . . .  | 78                             | —      | 24    | 102    | 96           | 3,919 00          |
| 1891, . . .  | 96                             | 5      | 49    | 150    | 135          | 2,668 00          |
| 1892, . . .  | 52                             | 12     | 72    | 136    | 123          | 3,661 70          |
| 1893, . . .  | 26                             | 3      | 67    | 96     | 92           | 2,476 00          |
| 1894, . . .  | 14                             | —      | 76    | 90     | 77           | 2,525 00          |
| 1895, . . .  | 13                             | 11     | 68    | 92     | 86           | 2,895 30          |
| Totals, . .  | 467                            | 38     | 626   | 1,131  | 1,028        | \$24,176 00       |

\* To May 1, 1886.

† Four months only.

‡ No record kept.

Ratio of convictions to complaints, 90.9 per cent.

NOTE. — All complaints entered before May 1, 1886, were under the direction of the Board of Health, Lunacy and Charity, and all after that date were under the direction of the State Board of Health.

The following report was presented to the Legislature in January, 1896, in compliance with the provisions of the statutes: —

OFFICE OF THE STATE BOARD OF HEALTH,  
STATE HOUSE, BOSTON, Jan. 9, 1896.

*To the Honorable Senate and House of Representatives of the Commonwealth of Massachusetts in General Court assembled.*

The following summary is made in compliance with the provisions of chapter 289, section 2, of the Acts of 1884, requiring the State Board of Health to "report annually to the Legislature the number of prosecutions made under chapter 263 of the Acts of 1882, and an itemized account of all money expended in carrying out the provisions thereof."

The whole number of prosecutions made by authority of the Board against offenders, under the provisions of the food and drug acts, for the year ending Sept. 30, 1895, was 92.

The cities and towns in which the articles were sold, and in respect to which complaints were entered in court, the character of the articles found to be adulterated, or fraudulently sold, the dates of the trials and their results, are presented in the following table:—

## MILK AND MILK PRODUCTS.

*For Fraudulent Sales of Milk.*

| PLACE.                  | DATE.                   | RESULT.     |
|-------------------------|-------------------------|-------------|
| In Marlborough, . . . . | Oct. 6, 1894, . . . .   | Convicted.  |
| Marlborough, . . . .    | Oct. 6, 1894, . . . .   | "           |
| Marlborough, . . . .    | Aug. 19, 1895, . . . .  | "           |
| Newton, . . . .         | Oct. 19, 1894, . . . .  | "           |
| Fall River, . . . .     | Oct. 5, 1894, . . . .   | "           |
| Fall River, . . . .     | Oct. 11, 1894, . . . .  | "           |
| Fall River, . . . .     | Oct. 11, 1894, . . . .  | "           |
| Gloucester, . . . .     | Nov. 3, 1894, . . . .   | "           |
| Gloucester, . . . .     | Nov. 3, 1894, . . . .   | Discharged. |
| Gloucester, . . . .     | May 22, 1895, . . . .   | Convicted.  |
| Gloucester, . . . .     | Aug. 16, 1895, . . . .  | "           |
| Chelsea, . . . .        | Nov. 30, 1894, . . . .  | "           |
| Chelsea, . . . .        | Nov. 7, 1894, . . . .   | "           |
| Salem, . . . .          | Dec. 21, 1894, . . . .  | "           |
| Salem, . . . .          | Feb. 26, 1895, . . . .  | "           |
| Salem, . . . .          | May 3, 1895, . . . .    | "           |
| Woburn, . . . .         | Nov. 29, 1894, . . . .  | "           |
| Woburn, . . . .         | May 10, 1895, . . . .   | "           |
| Woburn, . . . .         | Aug. 21, 1895, . . . .  | "           |
| Waltham, . . . .        | March 8, 1895, . . . .  | "           |
| Springfield, . . . .    | March 22, 1895, . . . . | Discharged. |
| Springfield, . . . .    | March 22, 1895, . . . . | Convicted.  |
| Springfield, . . . .    | April 5, 1895, . . . .  | "           |
| Chicopee, . . . .       | June 28, 1895, . . . .  | "           |
| Medford, . . . .        | Aug. 23, 1895, . . . .  | "           |
| Lowell, . . . .         | Sept 6, 1895, . . . .   | "           |
| Milford, . . . .        | Oct. 18, 1894, . . . .  | "           |
| Mendon, . . . .         | Oct. 18, 1894, . . . .  | "           |
| Wrentham, . . . .       | Oct. 20, 1894, . . . .  | "           |
| Gardner, . . . .        | Nov. 24, 1894, . . . .  | "           |
| West Medway, . . . .    | Nov. 24, 1894, . . . .  | "           |
| West Medway, . . . .    | Nov. 24, 1894, . . . .  | "           |
| Danvers, . . . .        | Jan. 18, 1895, . . . .  | "           |
| Danvers, . . . .        | Feb. 26, 1895, . . . .  | "           |
| Peabody, . . . .        | Jan. 26, 1895, . . . .  | "           |
| Peabody, . . . .        | Jan. 28, 1895, . . . .  | "           |
| Peabody, . . . .        | Feb. 19, 1895, . . . .  | "           |

*For Fraudulent Sales of Milk — Concluded.*

| PLACE.                    | DATE.                   | RESULT.     |
|---------------------------|-------------------------|-------------|
| In Peabody, . . . .       | Feb. 26, 1895, . . . .  | Convicted.  |
| Peabody, . . . .          | May 21, 1895, . . . .   | "           |
| Peabody, . . . .          | May 21, 1895, . . . .   | "           |
| Peabody, . . . .          | May 21, 1895, . . . .   | "           |
| Peabody, . . . .          | Aug. 14, 1895, . . . .  | "           |
| Peabody, . . . .          | Aug. 14, 1895, . . . .  | "           |
| Peabody, . . . .          | Aug. 14, 1895, . . . .  | "           |
| North Brookfield, . . . . | March 19, 1895, . . . . | "           |
| Bedford, . . . .          | March 12, 1895, . . . . | "           |
| Bedford, . . . .          | July 22, 1895, . . . .  | "           |
| Natick, . . . .           | July 26, 1895, . . . .  | "           |
| Ashland, . . . .          | July 26, 1895, . . . .  | "           |
| Norwell, . . . .          | April 26, 1895, . . . . | "           |
| North Pembroke, . . . .   | April 30, 1895, . . . . | "           |
| West Springfield, . . . . | May 6, 1895, . . . .    | Discharged. |
| Sherborn, . . . .         | May 15, 1895, . . . .   | "           |
| Dover, . . . .            | May 16, 1895, . . . .   | "           |
| Watertown, . . . .        | July 19, 1895, . . . .  | "           |
| Milton, . . . .           | July 12, 1895, . . . .  | "           |
| Billerica, . . . .        | July 22, 1895, . . . .  | "           |
| Deerfield, . . . .        | July 25, 1895, . . . .  | "           |
| Barre, . . . .            | July 29, 1895, . . . .  | "           |
| Framingham, . . . .       | July 31, 1895, . . . .  | "           |
| Westford, . . . .         | Aug. 2, 1895, . . . .   | "           |
| Wenham, . . . .           | Aug. 5, 1895, . . . .   | "           |
| Dedham, . . . .           | Sept. 23, 1895, . . . . | "           |
| Holliston, . . . .        | Sept. 28, 1895, . . . . | "           |
| Holliston, . . . .        | Sept. 28, 1895, . . . . | "           |
| Southborough, . . . .     | Sept. 30, 1895, . . . . | "           |
| Total, . . . .            | . . . .                 | 66          |

*For Fraudulent Sale of Oleomargarine.*

|                     |                        |            |
|---------------------|------------------------|------------|
| In Peabody, . . . . | Feb. 27, 1895, . . . . | Convicted. |
| Peabody, . . . .    | May 21, 1895, . . . .  | "          |
| Total, . . . .      | . . . .                | 2          |

## FOR FRAUDULENT SALE OF OTHER ARTICLES OF FOOD.

*Molasses.*

|                    |                         |            |
|--------------------|-------------------------|------------|
| In Lowell, . . . . | March 18, 1895, . . . . | Convicted. |
|--------------------|-------------------------|------------|

*Coffee.*

|                      |                         |             |
|----------------------|-------------------------|-------------|
| In Lawrence, . . . . | Oct. 27, 1894, . . . .  | Convicted.  |
| Chelsea, . . . .     | Dec. 19, 1894, . . . .  | Discharged. |
| Holyoke, . . . .     | April 26, 1895, . . . . | Convicted.  |
| Boston, . . . .      | June 4, 1895, . . . .   | "           |

FOR FRAUDULENT SALE OF OTHER ARTICLES OF FOOD—*Concluded.**Cream of Tartar.*

| PLACE.                | DATE.                | RESULT.    |
|-----------------------|----------------------|------------|
| In North Adams, . . . | Nov. 20, 1894, . . . | Convicted. |

*Lard.*

|                      |                      |            |
|----------------------|----------------------|------------|
| In Fall River, . . . | March 6, 1895, . . . | Convicted. |
|----------------------|----------------------|------------|

*Maple Syrup.*

|                  |                       |            |
|------------------|-----------------------|------------|
| In Lowell, . . . | March 18, 1895, . . . | Convicted. |
|------------------|-----------------------|------------|

*Honey.*

|                      |                       |            |
|----------------------|-----------------------|------------|
| In Fall River, . . . | March 22, 1895, . . . | Convicted. |
|----------------------|-----------------------|------------|

*Spices and Condiments.*

|                   |                                 |            |
|-------------------|---------------------------------|------------|
| In Holyoke, . . . | April 26, 1895 (cassia), . . .  | Convicted. |
| Holyoke, . . .    | April 26, 1895 (pepper), . . .  | "          |
| Holyoke, . . .    | April 26, 1895 (mustard), . . . | "          |
| Ware, . . .       | Jan. 4, 1895 (mustard), . . .   | "          |

## DRUGS.

|                   |                                               |            |
|-------------------|-----------------------------------------------|------------|
| In Gardner, . . . | Dec. 7, 1894 (Ruppert's Face Bleach), . . .   | Convicted. |
| Ware, . . .       | Dec. 4, 1894 (Ruppert's Face Bleach), . . .   | "          |
| Holyoke, . . .    | Dec. 19, 1894 (Ruppert's Face Bleach), . . .  | "          |
| Boston, . . .     | April —, 1895 (Ruppert's Face Bleach), . . .  | "          |
| Boston, . . .     | April —, 1895 (Ruppert's Face Bleach), . . .  | "          |
| Boston, . . .     | Dec. 31, 1894 (oxide of zinc ointment), . . . | Convicted. |
| Boston, . . .     | Dec. 31, 1894 (mercurial ointment), . . .     | "          |
| Woburn, . . .     | Dec. 2, 1894 (distilled water), . . .         | "          |
| Ware, . . .       | Dec. 11, 1894 (distilled water), . . .        | "          |
| Ware, . . .       | Dec. 8, 1894 (distilled water), . . .         | "          |
| Revere, . . .     | Aug. 9, 1895 (distilled water), . . .         | "          |

## SUMMARY.

|                                                                                                        |    |
|--------------------------------------------------------------------------------------------------------|----|
| Complaints entered in court under the acts relating to the inspection of milk and milk products, . . . | 68 |
| Other articles of food, . . .                                                                          | 13 |
| Drugs, . . .                                                                                           | 11 |
| Total, . . .                                                                                           | 92 |

## SUMMARY.

The whole number of complaints entered by the State Board of Health during the year ending Sept. 30, 1895, in the courts of the Commonwealth, against parties for violation of the statutes relating to food and drug inspection, was 92.

---

\* Parties left the State before case could be tried.

In 86, or 93.5 per cent., of these the parties were convicted. Four were discharged either in the district, municipal or superior courts, and in two cases the parties had left the State before warrants could be served.

Of the whole number, 66 were for violation of the laws relating to milk adulteration, and of this number 63 resulted in conviction. The greater number of these was for violation of the statute providing that milk offered for sale shall be of good standard quality.

In 1 of the foregoing cases the complaint was for sale of milk from a can not properly marked, 5 cases were for sales of milk containing coloring matter, and 1 was for a sale of milk containing boracic acid.

In one of the cases the defendant was discharged because his counsel would not admit the affidavit of the chemist as evidence.

In another case, in which the complaint was made for a sale of adulterated coffee, the defendant was discharged because the judge decided that it was not necessary to mark retail packages as "compound" in cases where the article was bought in bulk from a larger box or bin, to which the word "compound" was affixed.

The attention of the Legislature is respectfully called to the fact that, in consequence of the enactment of chapter 425 of the Acts of 1894, "relative to the inspection of milk," the defendants in two cases of milk adulteration which recently occurred in Franklin County were discharged. The actual amount of adulteration in these two cases was excessive, amounting to 40 or 50 per cent. of the samples in question.

Of the 13 complaints for fraudulent sales of other kinds of food, all of the parties were convicted except one. The articles of food embraced in this list were as follows:—

Molasses, 1 case; coffee, 4 cases; mustard, 2 cases; cream of tartar, 1 case; honey, 1 case; pepper, 1 case; cassia, 1 case; lard, 1 case; maple syrup, 1 case.

The standard of whole milk in Massachusetts is 13 per cent. of solid residue, except in May and June, when it is 12 per cent. The following list presents the total solids in all the samples of milk upon which complaints were founded, so far as records of the same were kept:—

|      |       |       |       |       |
|------|-------|-------|-------|-------|
| 6.66 | 10.24 | 10.63 | 11.05 | 11.42 |
| 7.44 | 10.26 | 10.72 | 11.12 | 11.46 |
| 8.79 | 10.30 | 10.80 | 11.16 | 11.46 |
| 8.90 | 10.38 | 10.84 | 11.16 | 11.57 |
| 9.22 | 10.38 | 10.86 | 11.18 | 11.58 |
| 9.60 | 10.40 | 10.86 | 11.26 | 11.65 |
| 9.63 | 10.42 | 10.87 | 11.27 | 11.66 |
| 9.84 | 10.47 | 10.87 | 11.28 | 11.70 |
| 9.87 | 10.56 | 10.90 | 11.30 | 11.80 |
| 9.89 | 10.56 | 10.90 | 11.35 | 11.89 |
| 9.92 | 10.58 | 10.92 | 11.37 | 11.93 |
| 9.92 | 10.62 | 10.92 | 11.40 | 12.46 |

total number of samples of food and drugs examined during the year as follows:—

|                                                      |             |
|------------------------------------------------------|-------------|
| articles of food,                                    | 3,712       |
| drugs,                                               | 2,971       |
| total,                                               | 544         |
| expenses of collection, examination and prosecution, | 7,227       |
| per expense per sample collected,                    | \$11,375 89 |
|                                                      | 1 57        |

#### FINES.

amount of fines paid into the treasuries of counties, cities and towns under the provisions of the general and special laws relative to the inspection of food and drugs was as follows:—

*paid for Violation of the Food and Drug Acts, upon Cases entered for the Year ending Sept. 30, 1895.*

|                                                                          |            |
|--------------------------------------------------------------------------|------------|
| the provisions of the laws relating to milk and milk products,           | \$2,652 62 |
| the provisions of the laws relating to other articles of food and drugs, | 242 68     |
| total,                                                                   | \$2,895 30 |

#### EXPENDITURES

*the Provisions of the Food and Drug Acts during the Year ending Sept. 30, 1895.*

|                                              | FOR THE ENFORCEMENT OF THE STATUTES<br>RELATING TO FOOD AND DRUG<br>INSPECTION. |                                                  |
|----------------------------------------------|---------------------------------------------------------------------------------|--------------------------------------------------|
|                                              | Relative to Milk<br>and Milk Products.                                          | Relative to Other<br>Kinds of Food and<br>Drugs. |
| salaries of analysts,                        | \$2,700 01                                                                      | \$1,800 00                                       |
| salaries of inspectors,                      | 2,400 00                                                                        | 1,563 82                                         |
| traveling expenses and purchase of supplies, | 1,100 00                                                                        | 725 00                                           |
| apparatus and chemicals,                     | 577 05                                                                          | 834 71                                           |
| freight,                                     | 2 40                                                                            | 1 60                                             |
| postage,                                     | 1 44                                                                            | 96                                               |
| miscellaneous services,                      | 1 68                                                                            | 1 12                                             |
| purchase of small supplies,                  | 45 00                                                                           | —                                                |
| other services,                              | 17 76                                                                           | 11 84                                            |
|                                              | 55 20                                                                           | 36 80                                            |
|                                              | \$6,900 54                                                                      | \$4,475 35                                       |
|                                              |                                                                                 | 6,900 54                                         |
| total,                                       |                                                                                 | \$11,375 89                                      |

SAM'L W. ABBOTT,  
Secretary of State Board of Health.





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## REPORTS OF THE ANALYSTS.

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# REPORTS OF THE ANALYSTS.

Dr. S. W. ABBOTT, *Secretary of the State Board of Health.*

DEAR SIR:—I have the honor to report the analysis of food and drugs for the year beginning Oct. 1, 1894, and ending Sept. 30, 1895.

## MILK.

The number of samples of milk analyzed in the State House laboratory during the year was larger than that of any previous year, and includes all the milk collected by the three inspectors of the Board throughout the State, exclusive of that from the four western counties, the examination of which is done at Amherst.

As usual, the total solids of every sample of milk submitted to us were determined gravimetrically, and those found below 12 per cent. total solids were further analyzed for fat. The methods of analysis were the same as those employed in previous years, viz., the determination of the solids by evaporation and of the fat by means of the Babcock process.

A careful examination was also made in suspected cases for color, preservatives, etc.

The ratio of samples found to be below the standard for the year is shown to be 51.5 per cent., being nearly identical with that of the preceding year, which was 51 per cent.

The following table shows the quality of the milk by months, and the percentage of adulteration of each month, corresponding to a standard of 13 per cent. and 12 per cent. respectively:—

*Quality of Milk by Months.*

| MONTHS.              | Total Samples Collected. | Above 13 Per Cent. | Below 13 Per Cent. | Below 12 Per Cent. | Ratio below 13 Per Cent. Standard. | Ratio below 12 Per Cent. Standard. |
|----------------------|--------------------------|--------------------|--------------------|--------------------|------------------------------------|------------------------------------|
| October, . . . . .   | 265                      | 120                | 145                | 43                 | 54.7                               | 16.2                               |
| November, . . . . .  | 165                      | 87                 | 78                 | 17                 | 47.3                               | 10.3                               |
| December, . . . . .  | 225                      | 111                | 114                | 20                 | 50.7                               | 8.8                                |
| January, . . . . .   | 252                      | 126                | 126                | 31                 | 50.0                               | 12.3                               |
| February, . . . . .  | 275                      | 131                | 144                | 43                 | 52.4                               | 15.6                               |
| March, . . . . .     | 289                      | 115                | 174                | 42                 | 50.2                               | 14.5                               |
| April, . . . . .     | 241                      | 82                 | 159                | 34                 | 55.9                               | 14.1                               |
| May, . . . . .       | 297                      | 127                | 170                | 23                 | 57.2                               | 7.7                                |
| June, . . . . .      | 402                      | 127                | 275                | 79                 | 58.4                               | 19.6                               |
| July, . . . . .      | 375                      | 117                | 258                | 92                 | 58.8                               | 24.5                               |
| August, . . . . .    | 370                      | 117                | 253                | 72                 | 58.3                               | 19.4                               |
| September, . . . . . | 393                      | 117                | 276                | 83                 | 70.2                               | 21.1                               |
|                      | 3,549                    | 1,377              | 2,172              | 579                | 51.2                               | 16.3                               |

It will be seen that under a standard of 13 per cent. throughout the entire year the ratio of samples below the standard would be 61.2 per cent., while with a 12 per cent. standard for the year the ratio would be only 16.3 per cent., so that the relative showing for the year is largely dependent on legislative enactment.

The following tables show the sources of the various samples of milk examined, apportioned among the cities, towns and suspected producers :—

*Milk from Cities.*

| CITIES.                | Total<br>Samples<br>Collected. | Above<br>Standard. | Below<br>Standard. | Per Cent.<br>below<br>Standard. | Total<br>Solids in<br>Lowest<br>Sample. | Number<br>of<br>Skimmed<br>Samples. | Number<br>of<br>Colored<br>Samples. |
|------------------------|--------------------------------|--------------------|--------------------|---------------------------------|-----------------------------------------|-------------------------------------|-------------------------------------|
| Boston, . . . . .      | 191                            | 92                 | 99                 | 52.3                            | 9.66                                    | 3                                   | -                                   |
| Brockton, . . . . .    | 23                             | 16                 | 7                  | 30.4                            | 10.45                                   | -                                   | -                                   |
| Cambridge, . . . . .   | 383                            | 210                | 173                | 45.2                            | 10.27                                   | 3                                   | -                                   |
| Chelsea, . . . . .     | 179                            | 83                 | 96                 | 53.7                            | 10.74                                   | 4                                   | -                                   |
| Everett, . . . . .     | 121                            | 49                 | 72                 | 59.5                            | 10.84                                   | 2                                   | 4                                   |
| Fall River, . . . . .  | 84                             | 50                 | 34                 | 40.4                            | 10.60                                   | -                                   | -                                   |
| Fitchburg, . . . . .   | 12                             | 11                 | 1                  | 8.3                             | 9.50                                    | 3                                   | -                                   |
| Gloucester, . . . . .  | 106                            | 58                 | 48                 | 45.3                            | 8.80                                    | -                                   | 2                                   |
| Haverhill, . . . . .   | 13                             | 6                  | 7                  | 53.8                            | 11.18                                   | -                                   | -                                   |
| Lawrence, . . . . .    | 58                             | 37                 | 21                 | 36.2                            | 11.11                                   | 4                                   | -                                   |
| Malden, . . . . .      | 130                            | 62                 | 68                 | 52.3                            | 10.60                                   | 1                                   | -                                   |
| Marlborough, . . . . . | 10                             | 3                  | 7                  | 70.0                            | 11.65                                   | 2                                   | -                                   |
| Medford, . . . . .     | 130                            | 63                 | 67                 | 51.5                            | 11.10                                   | -                                   | 1                                   |
| Newburyport, . . . . . | 12                             | 7                  | 5                  | 41.6                            | 12.44                                   | -                                   | -                                   |
| Newton, . . . . .      | 92                             | 54                 | 38                 | 41.3                            | 10.52                                   | 1                                   | -                                   |
| North Adams, . . . . . | 13                             | 11                 | 2                  | 15.3                            | 12.08                                   | -                                   | -                                   |
| Quincy, . . . . .      | 44                             | 16                 | 28                 | 63.6                            | 11.15                                   | -                                   | -                                   |
| Salem, . . . . .       | 102                            | 56                 | 46                 | 45.1                            | 9.87                                    | -                                   | -                                   |
| Somerville, . . . . .  | 260                            | 125                | 135                | 51.9                            | 10.08                                   | 1                                   | -                                   |
| Taunton, . . . . .     | 24                             | 18                 | 6                  | 25.0                            | 11.28                                   | -                                   | -                                   |
| Waltham, . . . . .     | 56                             | 27                 | 29                 | 51.7                            | 10.27                                   | -                                   | 3                                   |
| Woburn, . . . . .      | 140                            | 46                 | 94                 | 67.1                            | 9.95                                    | -                                   | 16                                  |
| Worcester, . . . . .   | 22                             | 9                  | 13                 | 59.1                            | 11.66                                   | -                                   | -                                   |
| Totals, . . . . .      | 2,205                          | 1,109              | 1,096              | 49.7                            | 8.80                                    | 24                                  | 25                                  |

*Milk from Towns.*

| Towns.             | Total<br>Samples<br>Collected. | Above<br>Standard. | Below<br>Standard. | Per Cent.<br>below<br>Standard. | Total<br>Solids in<br>Lowest<br>Sample. | Number<br>of<br>Skimmed<br>Samples. | Number<br>of<br>Colored<br>Samples. |
|--------------------|--------------------------------|--------------------|--------------------|---------------------------------|-----------------------------------------|-------------------------------------|-------------------------------------|
| gton, . . . . .    | 3                              | 2                  | 1                  | 33.3                            | 11.50                                   | -                                   | -                                   |
| tree, . . . . .    | 5                              | 5                  | 0                  | 0.0                             | 12.40                                   | -                                   | -                                   |
| cline, . . . . .   | 96                             | 63                 | 33                 | 34.3                            | 11.54                                   | 1                                   | -                                   |
| n, . . . . .       | 23                             | 18                 | 5                  | 21.7                            | 11.87                                   | -                                   | -                                   |
| n, . . . . .       | 12                             | 4                  | 8                  | 66.6                            | 10.10                                   | 2                                   | -                                   |
| ers, . . . . .     | 6                              | 2                  | 4                  | 66.6                            | 11.42                                   | -                                   | -                                   |
| am, . . . . .      | 53                             | 34                 | 19                 | 35.8                            | 9.96                                    | -                                   | -                                   |
| inton, . . . . .   | 10                             | 4                  | 6                  | 60.0                            | 12.07                                   | -                                   | -                                   |
| . . . . .          | 19                             | 6                  | 13                 | 68.4                            | 10.90                                   | -                                   | -                                   |
| Park, . . . . .    | 60                             | 38                 | 22                 | 36.6                            | 11.30                                   | -                                   | -                                   |
| igton, . . . . .   | 10                             | 10                 | 0                  | 0.0                             | 12.00                                   | -                                   | -                                   |
| ee, . . . . .      | 9                              | 5                  | 4                  | 44.4                            | 12.44                                   | -                                   | -                                   |
| rd, . . . . .      | 12                             | 7                  | 5                  | 41.7                            | 11.26                                   | -                                   | -                                   |
| cket, . . . . .    | 14                             | 7                  | 7                  | 50.0                            | 10.79                                   | -                                   | -                                   |
| k, . . . . .       | 12                             | 8                  | 4                  | 33.3                            | 11.82                                   | -                                   | -                                   |
| dy, . . . . .      | 28                             | 4                  | 24                 | 85.7                            | 7.44                                    | -                                   | 1                                   |
| ncetown, . . . . . | 29                             | 10                 | 19                 | 65.1                            | 10.82                                   | 1                                   | -                                   |
| olph, . . . . .    | 10                             | 10                 | 0                  | 0.0                             | 12.73                                   | -                                   | -                                   |
| re, . . . . .      | 97                             | 47                 | 50                 | 51.5                            | 11.49                                   | 1                                   | -                                   |
| ury, . . . . .     | 24                             | 17                 | 7                  | 29.2                            | 11.55                                   | -                                   | -                                   |
| ham, . . . . .     | 96                             | 59                 | 37                 | 38.5                            | 10.25                                   | -                                   | -                                   |
| ghton, . . . . .   | 33                             | 25                 | 8                  | 24.2                            | 9.78                                    | 1                                   | -                                   |
| , . . . . .        | 12                             | 10                 | 2                  | 16.6                            | 12.25                                   | -                                   | -                                   |
| ham, . . . . .     | 81                             | 12                 | 19                 | 61.3                            | 10.37                                   | -                                   | -                                   |
| rtown, . . . . .   | 26                             | 16                 | 10                 | 34.6                            | 10.65                                   | 1                                   | -                                   |
| mouth, . . . . .   | 10                             | 9                  | 1                  | 10.0                            | 9.74                                    | -                                   | -                                   |
| hester, . . . . .  | 46                             | 26                 | 20                 | 43.4                            | 11.34                                   | 1                                   | -                                   |
| hrop, . . . . .    | 15                             | 8                  | 7                  | 46.6                            | 11.62                                   | -                                   | -                                   |
| Totals, . . . . .  | 801                            | 466                | 335                | 41.8                            | 7.44                                    | 8                                   | 1                                   |

*Milk from Suspected Producers.*

| LOCALITY.                   | Total Samples Collected. | Above Standard | Below Standard. | Per Cent. below Standard. | Total Solids in Lowest Sample. | Number of Colored Samples. |
|-----------------------------|--------------------------|----------------|-----------------|---------------------------|--------------------------------|----------------------------|
| Ashland, . . . . .          | 5                        | 0              | 5               | 100.0                     | 10.80                          | -                          |
| Athol, . . . . .            | 5                        | 1              | 4               | 80.0                      | 9.84                           | -                          |
| Barre, . . . . .            | 20                       | 14             | 6               | 30.0                      | 11.12                          | -                          |
| Bedford, . . . . .          | 52                       | 2              | 50              | 96.1                      | 9.92                           | -                          |
| Berlin, . . . . .           | 6                        | 0              | 6               | 100.0                     | 11.35                          | -                          |
| Billerica, . . . . .        | 5                        | 0              | 5               | 100.0                     | 10.87                          | -                          |
| Bolton, . . . . .           | 6                        | 0              | 6               | 100.0                     | 11.54                          | -                          |
| Boylston, . . . . .         | 10                       | 0              | 10              | 100.0                     | 11.14                          | -                          |
| Burlington, . . . . .       | 12                       | 12             | 0               | 0.0                       | 12.14                          | -                          |
| Canton, . . . . .           | 12                       | 0              | 12              | 100.0                     | 11.55                          | -                          |
| Danvers, . . . . .          | 10                       | 4              | 6               | 60.0                      | 12.20                          | -                          |
| Dedham, . . . . .           | 10                       | 0              | 10              | 100.0                     | 9.84                           | -                          |
| Deerfield, . . . . .        | 12                       | 1              | 11              | 91.6                      | 6.66                           | -                          |
| Dover, . . . . .            | 14                       | 1              | 13              | 92.8                      | 10.63                          | -                          |
| Faulkner, . . . . .         | 22                       | 0              | 22              | 100.0                     | 10.37                          | -                          |
| Framlingham, . . . . .      | 7                        | 2              | 5               | 71.4                      | 10.24                          | -                          |
| Franklin, . . . . .         | 2                        | 0              | 2               | 100.0                     | 9.60                           | -                          |
| Gardner, . . . . .          | 15                       | 0              | 15              | 100.0                     | 11.53                          | -                          |
| Grafton, . . . . .          | 5                        | 0              | 5               | 100.0                     | 11.32                          | -                          |
| Hardwick, . . . . .         | 19                       | 12             | 7               | 36.8                      | 11.43                          | -                          |
| Holliston, . . . . .        | 9                        | 2              | 7               | 77.7                      | 10.86                          | -                          |
| Leominster, . . . . .       | 8                        | 5              | 3               | 37.5                      | 11.36                          | -                          |
| Medfield, . . . . .         | 16                       | 3              | 13              | 81.2                      | 9.22                           | -                          |
| Medford, . . . . .          | 12                       | 4              | 8               | 66.6                      | 12.33                          | 11                         |
| Milton, . . . . .           | 20                       | 13             | 7               | 35.0                      | 10.92                          | -                          |
| Natick, . . . . .           | 15                       | 2              | 13              | 86.6                      | 11.08                          | -                          |
| Norwell, . . . . .          | 3                        | 0              | 3               | 100.0                     | 11.93                          | -                          |
| Northborough, . . . . .     | 18                       | 0              | 18              | 100.0                     | 10.64                          | -                          |
| North Brookfield, . . . . . | 12                       | 0              | 12              | 100.0                     | 9.89                           | -                          |
| Pembroke, . . . . .         | 4                        | 0              | 4               | 100.0                     | 11.16                          | -                          |
| Royalston, . . . . .        | 7                        | 0              | 7               | 100.0                     | 8.53                           | -                          |
| Sherborn, . . . . .         | 19                       | 4              | 15              | 78.9                      | 10.90                          | -                          |
| Southborough, . . . . .     | 8                        | 0              | 8               | 100.0                     | 10.49                          | -                          |
| Sudbury, . . . . .          | 19                       | 1              | 18              | 94.7                      | 10.17                          | -                          |
| Stow, . . . . .             | 36                       | 15             | 21              | 58.3                      | 10.96                          | -                          |
| Upton, . . . . .            | 11                       | 4              | 7               | 63.6                      | 10.84                          | -                          |
| Walpole, . . . . .          | 4                        | 4              | 0               | 0.0                       | 12.02                          | -                          |
| Waltham, . . . . .          | 23                       | 13             | 10              | 43.4                      | 12.08                          | -                          |
| Wenham, . . . . .           | 12                       | 8              | 4               | 33.3                      | 10.87                          | -                          |
| Westborough, . . . . .      | 12                       | 0              | 12              | 100.0                     | 11.04                          | -                          |
| Westford, . . . . .         | 4                        | 0              | 4               | 100.0                     | 9.92                           | -                          |
| Weston, . . . . .           | 3                        | 3              | 0               | 0.0                       | 13.07                          | -                          |
| Totals, . . . . .           | 524                      | 130            | 394             | 75.2                      | 6.66                           | 11                         |

*Summary of the Three Preceding Tables.*

|                                | Total Samples Collected. | Above Standard. | Below Standard. | Per Cent. below Standard. | Total Solids in Lowest Sample. | Number of Skimmed Samples. | Number of Colored Samples |
|--------------------------------|--------------------------|-----------------|-----------------|---------------------------|--------------------------------|----------------------------|---------------------------|
| Cities, . . . . .              | 2,205                    | 1,109           | 1,096           | 49.7                      | 8.80                           | 24                         | 26                        |
| Towns, . . . . .               | 801                      | 466             | 335             | 41.7                      | 7.44                           | 8                          | 1                         |
| Suspected producers, . . . . . | 524                      | 130             | 394             | 75.2                      | 6.66                           | -                          | 11                        |
| Miscellaneous, . . . . .       | 19                       | 15              | 4               | 21.0                      | -                              | -                          | -                         |
|                                | 3,649                    | 1,720           | 1,829           | 51.5                      | 6.66                           | 32                         | 38                        |

The number of milk samples collected from producers was considerably larger than usual, and a much larger number of towns than usual is included in this list.

The number of colored samples found during the year is unusually large. Annatto was the favorite coloring matter employed. While in most instances the color was added to conceal evidence of watering, a number of cases were found in which the milk itself was considerably above the standard, though containing added coloring matter.

Several samples of milk were found to contain an added coal tar color. It was found to be a mixture of two or more of the orange members of the diazo compounds of aniline. A mixture of the dyes known to the trade as "Orange G" and "Fast Yellow" gives a color which is essentially identical with this milk color.

For its detection in the milk it was found sufficient to curdle about half a pint of the heated milk with acetic acid, so as to separate the casein in one mass. The whey being poured off, the orange dye, if present, is readily detected in the curd by macerating with ether for some time, preferably over night. The natural color of the milk left in the curd is entirely dissolved out by the ether, as is annatto or any of the common vegetable coloring matters, leaving the curd a pure white. The coal tar dye, on the contrary, is not dissolved out by ether, and, on pouring off the latter, the dye is readily apparent, if present, by the persistent deep yellow or orange color of the curd.

Among a number of samples of milk brought in by one of the inspectors was found a sample can containing water colored with caramel, with the addition also of common salt. This colored water, it was afterwards ascertained, was found by the inspector in an eight-quart can nearly full, among a number of milk cans in a dealer's wagon. Its obvious use was to both water and color at the same time milk delivered in small cans from house to house. This method of treating the milk at the time of its delivery was doubtless considered by the dealer as a very clever dodge, in that the milk taken from his wagon would undoubtedly be found to be of good quality.

The lowest sample of milk analyzed this year contained 6.66 per cent. total solids, of which 2.25 per cent. was fat. This was taken from a farmer, and was one of a lot of milk samples which was, with one exception, the worst lot ever analyzed by the Board.

Bearing on the question so often asked in court as to the degree of accuracy attainable in parallel analyses of the same milk, and as to the closeness of agreement in analyses of the same milk by different chemists, an opportunity was afforded during the year to practically test this point.



A certain milk dealer was suspected of having tampered with sealed samples of milk given him by an inspector to the extent of removing the milk contained in the sealed bottles delivered to him by the inspector (which milk was of poor quality) and replacing it by other milk of good quality, afterwards fixing the seals so as not to be detected, and taking the samples to an outside chemist for analysis. The wide difference in the results obtained by the outside chemist and those of the Board's analyst (amounting in one case to about 3 per cent. of milk solids) led to a second raid on the dealer by the inspector, who was instructed to make several sealed samples of each milk taken, in order that check analyses might be made by different chemists. Following is a summary of the results in percentage of total solids obtained and reported independently by three analysts on the nine samples of milk so taken : —

|          |       |       |       |          |       |       |       |
|----------|-------|-------|-------|----------|-------|-------|-------|
| A, . . . | 13.10 | 13.11 | 13.02 | F, . . . | 13.64 | 13.60 | 13.62 |
| B, . . . | 12.60 | 12.54 | 12.50 | G, . . . | 14.03 | 13.90 | 13.96 |
| C, . . . | 12.74 | 12.76 | 12.78 | H, . . . | 12.42 | 12.42 | 12.40 |
| D, . . . | 12.84 | 12.77 | 12.78 | I, . . . | 12.62 | 12.69 | 12.70 |
| E, . . . | 11.42 | 11.43 | 11.46 |          |       |       |       |

None of the milk samples examined during the year were found to contain any added preservative.

#### *Condensed Milk.*

The accompanying table shows the results of the analysis of as many brands of condensed milk as could conveniently be obtained. The quality of the milk used is shown to be in nearly every instance all that could be desired, and it would seem as if the popular idea that condensed milk is usually made from skimmed milk is erroneous.

The method of analysis employed, adapted from that of H. B. Cornwall, consisted in first weighing out 40 grammes of the thoroughly mixed sample and making up to 100 cubic centimeters with water. Portions of this solution were taken for the various determinations, as follows :—

*Total Solids.*—An aliquot part of the above 40 per cent. solution was further diluted with an equal amount of water, and 5 cubic centimeters of the diluted mixture (corresponding to 1 gramme of the condensed milk) was evaporated, dried and weighed in a platinum dish.

*Ash.* — The residue from the total solids as above obtained was burned and weighed.

*Fat.* — Five cubic centimeters of the 40 per cent. solution (corresponding to 2 grammes of the condensed milk) was absorbed by a coil of filter paper which was dried in an air oven at 100° C., and the fat extracted by ether in a Soxhlet extractor.

*Proteids.* — Five cubic centimeters of the 40 per cent. solution was further diluted to about 40 cubic centimeters, and just enough of a very weak solution of copper sulphate was added to precipitate the albuminoids, which slowly settled, leaving a perfectly clear solution of the whey, free from copper. The precipitate was filtered through a weighed filter, washed and afterwards dried in the air oven and weighed. The filter with the dried precipitate was then incinerated in a porcelain crucible, and the weight of the ash minus that of the dried precipitate gave the weight of the proteids and fat. Deducting the percentage of fat, already obtained, from that of the proteids and fat, left the percentage of proteids.

*Milk Sugar.* — The filtrate and the washings from the preceding operation were made up to 100 cubic centimeters with water, and the amount of reducing sugar obtained volumetrically by Fehling's solution was reckoned as milk sugar.

*Cane Sugar.* — This was obtained by difference, deducting the total milk solids (milk sugar + proteids + fat + ash) from the total solids first obtained.

*Condensed Milk.*

| Inspector's Number. | Brand.                     | Total Solids. | Water. | Milk Solids. | Cane Sugar. | Milk Sugar. | Proteids. | Fat.  | Ash. | Fat in Original Milk.* | Number of Times Condensed * | Price Paid per Can. |
|---------------------|----------------------------|---------------|--------|--------------|-------------|-------------|-----------|-------|------|------------------------|-----------------------------|---------------------|
| 19059, . . . .      | Anglo Swiss, . . . .       | 75.30         | 24.70  | 36.03        | 39.27       | 14.13       | 9.45      | 10.80 | 1.65 | 3.98                   | 2.7                         | .18                 |
| 19088, . . . .      | Standard, . . . .          | 72.37         | 27.63  | 35.78        | 36.59       | 16.75       | 7.40      | 9.63  | 2.00 | 3.42                   | 2.8                         | .10                 |
| 20985, . . . .      | Baby, . . . .              | 75.52         | 24.48  | 33.26        | 42.26       | 12.18       | 7.27      | 11.95 | 1.86 | 5.21                   | 2.3                         | .18                 |
| 19079, . . . .      | Rose, . . . .              | 72.05         | 27.95  | 32.42        | 39.63       | 11.51       | 8.33      | 10.88 | 1.70 | 4.69                   | 2.3                         | .13                 |
| 19128, . . . .      | Bell, . . . .              | 70.32         | 29.68  | 32.77        | 37.55       | 13.96       | 7.55      | 9.44  | 1.82 | 3.76                   | 2.5                         | .09                 |
| 9707f, . . . .      | Sweet Clover, . . . .      | 72.82         | 27.18  | 29.32        | 43.50       | 12.18       | 8.95      | 9.68  | 1.51 | 4.58                   | 2.1                         | .10                 |
| 13g, . . . .        | J. E. Smith, . . . .       | 69.15         | 30.85  | 32.65        | 36.50       | 13.84       | 7.84      | 9.25  | 1.72 | 3.67                   | 2.5                         | -                   |
| 19087, . . . .      | Tip Top, . . . .           | 70.40         | 29.60  | 34.35        | 36.05       | 12.73       | 9.39      | 10.54 | 1.69 | 4.11                   | 2.5                         | .09                 |
| 19252, . . . .      | Challenge, . . . .         | 70.50         | 29.50  | 32.22        | 38.28       | 11.43       | 8.32      | 10.80 | 1.67 | 4.68                   | 2.3                         | .10                 |
| 19086, . . . .      | Rose, . . . .              | 75.30         | 24.70  | 39.76        | 35.54       | 20.06       | 7.52      | 10.23 | 1.95 | 3.18                   | 3.0                         | .10                 |
| 19091, . . . .      | Gall Borden Eagle, . . . . | 71.96         | 28.04  | 30.00        | 41.96       | 11.55       | 8.78      | 8.25  | 1.42 | 3.52                   | 2.3                         | .18                 |
| 907g, . . . .       | Sachm, . . . .             | 70.44         | 29.56  | 34.65        | 35.79       | 15.43       | 8.37      | 9.28  | 1.57 | 3.40                   | 2.7                         | .08                 |
| 19090, . . . .      | Leader, . . . .            | 74.56         | 25.44  | 29.94        | 44.62       | 12.69       | 5.96      | 9.72  | 1.57 | 4.47                   | 2.2                         | .09                 |
| 9927f, . . . .      | Sweet Clover, . . . .      | 71.70         | 28.30  | 27.52        | 44.18       | 9.71        | 7.00      | 9.52  | 1.29 | 5.47                   | 1.9                         | .10                 |
| 6351g, . . . .      | Magnolia, . . . .          | 70.89         | 29.11  | 31.44        | 39.45       | 11.75       | 7.58      | 10.43 | 1.68 | 4.61                   | 2.3                         | .10                 |
| 4059g, . . . .      | Rival, . . . .             | 74.04         | 25.96  | 30.85        | 43.19       | 14.69       | 6.42      | 8.42  | 1.32 | 3.49                   | 2.4                         | .10                 |
| 4679g, . . . .      | Buttercup, . . . .         | 65.90         | 34.10  | 26.98        | 38.92       | 7.03        | 9.25      | 9.18  | 1.50 | 4.77                   | 1.9                         | -                   |
| 6765g, . . . .      | Russel, . . . .            | 74.69         | 25.41  | 28.33        | 46.28       | 10.53       | 8.31      | 8.05  | 1.44 | 3.69                   | 2.2                         | -                   |
| 9717f, . . . .      | Ten Cent, . . . .          | 75.41         | 24.59  | 35.42        | 39.99       | 13.40       | 9.83      | 10.61 | 1.58 | 3.97                   | 2.7                         | .10                 |
| 21774, . . . .      | Pine Trees, . . . .        | 70.60         | 29.40  | 33.20        | 38.50       | 13.13       | 7.67      | 9.94  | 1.49 | 4.13                   | 2.4                         | .10                 |

|        |   |   |   |   |   |       |       |       |       |       |      |       |      |      |     |     |
|--------|---|---|---|---|---|-------|-------|-------|-------|-------|------|-------|------|------|-----|-----|
| 21764, | . | . | . | . | . | 11.13 | 20.00 | 25.89 | 35.00 | 45.49 | 5.83 | 9.25  | 1.90 | 6.10 | 4.0 | .00 |
| 21765, | . | . | . | . | . | 72.50 | 27.50 | 33.54 | 38.96 | 14.25 | 8.92 | 9.05  | 1.32 | 3.43 | 2.6 | .10 |
| 21766, | . | . | . | . | . | 75.25 | 24.75 | 35.72 | 39.53 | 18.93 | 7.39 | 7.80  | 1.60 | 2.59 | 3.0 | .10 |
| 21767, | . | . | . | . | . | 76.15 | 23.85 | 35.13 | 41.02 | 14.25 | 8.51 | 10.70 | 1.67 | 4.07 | 2.6 | .17 |
| 21768, | . | . | . | . | . | 72.42 | 27.58 | 29.65 | 42.77 | 7.05  | 8.90 | 12.84 | 1.86 | 6.64 | 1.9 | .15 |
| 21769, | . | . | . | . | . | 69.49 | 30.51 | 28.95 | 40.54 | 10.09 | 9.09 | 8.25  | 1.52 | 3.70 | 2.2 | .10 |
| 21770, | . | . | . | . | . | 72.73 | 27.27 | 34.36 | 38.37 | 18.84 | 8.89 | 10.35 | 1.78 | 4.00 | 2.6 | .18 |
| 21771, | . | . | . | . | . | 73.35 | 26.65 | 31.37 | 41.98 | 11.55 | 7.50 | 10.82 | 1.50 | 4.88 | 2.2 | .12 |
| 21772, | . | . | . | . | . | 75.43 | 24.57 | 34.53 | 40.90 | 14.44 | 7.92 | 10.52 | 2.65 | 4.07 | 2.6 | .18 |
| 21773, | . | . | . | . | . | 71.52 | 28.18 | 34.44 | 37.33 | 13.34 | 9.06 | 10.47 | 1.57 | 4.06 | 2.6 | .10 |
| 21774, | . | . | . | . | . | 71.32 | 28.68 | 28.77 | 42.65 | 10.94 | 8.47 | 8.03  | 1.33 | 3.60 | 2.2 | -   |
| 21775, | . | . | . | . | . | 72.10 | 27.90 | 34.06 | 38.04 | 16.53 | 8.51 | 7.45  | 1.52 | 2.60 | 2.8 | -   |
| 21776, | . | . | . | . | . | 69.00 | 31.00 | 29.36 | 39.64 | 11.92 | 6.90 | 9.13  | 1.41 | 4.19 | 2.2 | -   |

\* Assuming a standard of 9.3 per cent. for solids not fat.

*Condensed Milk.*

| Inspector's Number.          | Brand.                     | Total Solids. | Water. | Milk Solids. | Cane Sugar. | Milk Sugar. | Proteids. | Fat.  | Ash. | Fat in Original Milk.* | Number of Times Condensed * | Price Paid per Can. |
|------------------------------|----------------------------|---------------|--------|--------------|-------------|-------------|-----------|-------|------|------------------------|-----------------------------|---------------------|
| 19089, . . . .               | Anglo Swiss, . . . .       | 75.30         | 24.70  | 36.03        | 39.27       | 14.13       | 9.45      | 10.80 | 1.65 | 3.98                   | 2.7                         | .18                 |
| 19088, . . . .               | Standard, . . . .          | 72.37         | 27.63  | 35.78        | 36.59       | 16.75       | 7.40      | 9.63  | 2.00 | 3.42                   | 2.8                         | .10                 |
| 20985, . . . .               | Baby, . . . .              | 75.52         | 24.48  | 33.26        | 42.26       | 12.18       | 7.27      | 11.95 | 1.86 | 5.21                   | 2.3                         | .18                 |
| 19079, . . . .               | Rose, . . . .              | 72.05         | 27.95  | 32.42        | 39.63       | 11.51       | 8.33      | 10.88 | 1.70 | 4.69                   | 2.8                         | .13                 |
| 19128, . . . .               | Bell, . . . .              | 70.32         | 29.68  | 32.77        | 37.55       | 13.96       | 7.55      | 9.44  | 1.82 | 3.76                   | 2.5                         | .09                 |
| 9707 $\frac{1}{2}$ , . . . . | Sweet Clover, . . . .      | 72.82         | 27.18  | 29.32        | 43.50       | 12.18       | 5.95      | 9.68  | 1.51 | 4.58                   | 2.1                         | .10                 |
| 13g, . . . .                 | J. B. Smith, . . . .       | 69.15         | 30.85  | 32.65        | 36.50       | 13.84       | 7.84      | 9.25  | 1.72 | 3.67                   | 2.5                         | -                   |
| 19087, . . . .               | Tip Top, . . . .           | 70.40         | 29.60  | 34.35        | 36.05       | 12.73       | 9.39      | 10.54 | 1.69 | 4.11                   | 2.6                         | .09                 |
| 19252, . . . .               | Challenge, . . . .         | 70.50         | 29.50  | 32.22        | 38.28       | 11.43       | 8.32      | 10.80 | 1.67 | 4.68                   | 2.3                         | .10                 |
| 19086, . . . .               | Rose, . . . .              | 75.30         | 24.70  | 39.76        | 35.54       | 20.06       | 7.52      | 10.23 | 1.95 | 3.18                   | 3.0                         | .10                 |
| 19091, . . . .               | Gall Borden Eagle, . . . . | 71.96         | 28.04  | 30.00        | 41.96       | 11.55       | 8.78      | 8.25  | 1.42 | 3.52                   | 2.3                         | .18                 |
| 907g, . . . .                | Sachem, . . . .            | 70.44         | 29.56  | 34.65        | 35.79       | 15.43       | 8.37      | 9.28  | 1.57 | 3.40                   | 2.7                         | .08                 |
| 19090, . . . .               | Leader, . . . .            | 74.56         | 25.44  | 29.94        | 44.62       | 12.69       | 5.96      | 9.72  | 1.57 | 4.47                   | 2.2                         | .09                 |
| 9927 $\frac{1}{2}$ , . . . . | Sweet Clover, . . . .      | 71.70         | 28.30  | 27.52        | 44.18       | 9.71        | 7.00      | 9.52  | 1.29 | 5.47                   | 1.9                         | .10                 |
| 6351g, . . . .               | Magnolia, . . . .          | 70.89         | 29.11  | 31.44        | 39.45       | 11.75       | 7.58      | 10.43 | 1.68 | 4.61                   | 2.3                         | .10                 |
| 4059g, . . . .               | Rival, . . . .             | 74.04         | 25.96  | 30.85        | 43.19       | 14.69       | 6.42      | 8.42  | 1.32 | 3.49                   | 2.4                         | .10                 |
| 4679g, . . . .               | Buttercup, . . . .         | 65.90         | 34.10  | 26.98        | 38.92       | 7.06        | 9.25      | 9.18  | 1.50 | 4.77                   | 1.9                         | -                   |
| 6769g, . . . .               | Russel, . . . .            | 74.59         | 25.41  | 28.33        | 46.26       | 10.53       | 8.31      | 8.05  | 1.44 | 3.69                   | 2.3                         | -                   |
| 9717 $\frac{1}{2}$ , . . . . | Ten Cent, . . . .          | 75.41         | 24.59  | 35.42        | 39.99       | 13.40       | 9.83      | 10.61 | 1.58 | 3.97                   | 2.7                         | .10                 |
| 21774, . . . .               | Fine Tree, . . . .         | 70.60         | 29.40  | 32.20        | 38.80       | 13.13       | 7.67      | 9.91  | 1.49 | 4.13                   | 2.4                         | .10                 |



### BUTTER.

Of 191 samples 186 proved to be genuine.

The Zeiss refractometer has been largely used in quickly detecting the admixture or substitution of margarine. Samples that the refractometer indicated as containing margarine were analyzed by the Reichert process in confirmation.

### CHEESE.

Thirteen samples were found of good quality. One sample of skim-milk cheese was found.

### LARD.

The analysis of lard both in this country and abroad has recently attracted much attention, and many methods have been devised for detecting admixture of beef fat and cotton-seed oil, the chief adulterants. The tests chiefly relied upon in this laboratory have been the following:—

*Reaction with Strong Acid (Sulphuric or Nitric.)* — Genuine lard and beef tallow usually give but slight coloration, while mixtures of cotton-seed oil invariably give a red-brown color, more or less intense in proportion to the amount of cotton-seed oil present.

A genuine lard will, however, occasionally be found to give a strong color with acid.

*The Microscopic Examination of the Stearin Crystals Separated from an Ether-Alcohol Solution.* — The characteristic crystalline forms of lard and tallow stearin are shown in figs. 1, 2 and 3.

*The Hehner Modification of the Bechi Nitrate of Silver Test.* — A small amount of the sample is shaken with half its bulk of a standard alcoholic solution of nitrate of silver, made very slightly acid with nitric acid. The vessel containing this mixture is then immersed in boiling water for fifteen minutes. With proper precautions the presence of cotton-seed oil is indicated by a strong reduction of the silver, while pure lard or tallow in the absence of cotton-seed oil causes no appreciable reduction.

*The Refractometer Reading.* — The refractometer used is the Zeiss instrument, in which the degree of refraction of a reflected beam of light which passes obliquely through a thin film of the fat

read on an arbitrary scale. A constant temperature by means of circulation of heated water is maintained and its degree is noted. The refracting degree of cotton-seed oil is about 8.9 in excess of the standard refraction of lard, while that of tallow is about 3.8 less than the standard. This is shown by samples H and I in the following table.

The readings are quickly and easily taken, and, in connection with the positive Bechi test for cotton-seed oil and the crystallization test for beef stearin, the refractometer is of great value.

It will be noted that adulteration of lard with cotton-seed oil alone is indicated by an abnormally high refractometer number, while the presence of tallow will result in an abnormally low refraction. But both adulterants may be present and a normal refraction result. In such a case the positive detection of one of them, such as the cotton-seed oil by the Bechi test, will indirectly show the presence of the other (tallow), and this indirect proof will be confirmed by crystallization.

*The Iodine Absorption Number.* — This is perhaps the most important of all the tests, although its results are in general prefigured by the refractometer. By it is meant the percentage of iodine which a sample of fat will absorb.

As may be seen in the following table, cotton-seed oil (H) will absorb about 108 per cent. of its weight of iodine, while beef fat (I) will absorb but about 37 per cent.



*Table showing Analysis of Samples, Illustrating Types of Lard and its Substitutes.*

|   | ACID REACTION.         | Crystallization.     | Bechl Reaction. | REFRACTOMETER.    |        |                                | Iodine Number. | Conclusion.                               |
|---|------------------------|----------------------|-----------------|-------------------|--------|--------------------------------|----------------|-------------------------------------------|
|   |                        |                      |                 | Temper-<br>ature. | Index. | Variation<br>from<br>Standard. |                |                                           |
| A | Slight color, . . . .  | Lard, . . . .        | None, . . . .   | 42.3              | 49.7   | +0.1                           | 58.1           | Lard.                                     |
| B | Red, . . . .           | Lard, . . . .        | None, . . . .   | 42.               | 50.    | +0.2                           | 59.9           | Lard.                                     |
| C | Slight color, . . . .  | Lard, . . . .        | None, . . . .   | 41.5              | 50.1   | +0.0                           | 58.7           | Lard.                                     |
| D | Slight color, . . . .  | Lard, . . . .        | None, . . . .   | 42.8              | 50.    | +0.6                           | 63.7           | Lard.                                     |
| E | Slight color, . . . .  | Lard, . . . .        | None, . . . .   | 41.3              | 51.    | +0.8                           | 64.6           | Lard.                                     |
| F | Slight color, . . . .  | Lard, . . . .        | None, . . . .   | 42.               | 50.5   | +0.7                           | 64.8           | Lard.                                     |
| G | Slight color, . . . .  | Lard, . . . .        | None, . . . .   | 42.               | 49.7   | -0.1                           | 55.4           | Leaf lard.                                |
| H | Very slight color, . . | Tallow, . . . .      | None, . . . .   | 50.               | 41.2   | -3.8                           | 37.3           | Beef tallow.                              |
| I | Deep brown, red, . .   | Few small bunches, . | Deep color, . . | 42.               | 53.7   | +8.9                           | 108.           | Cotton-seed oil.                          |
| J | Red, . . . .           | Lard, . . . .        | Deep color, . . | 43.               | 50.5   | +1.3                           | 69.5           | Lard and cotton-seed oil.                 |
| K | Very slight color, . . | Lard and tallow, . . | None, . . . .   | 43.               | 48.5   | -0.7                           | 55.2           | Lard and beef tallow.                     |
| L | Deep brown, . . . .    | Lard, . . . .        | Deep color, . . | 43.5              | 51.    | +1.1                           | 71.4           | Lard and cotton seed oil.                 |
| M | Red, . . . .           | Lard, . . . .        | Deep color, . . | 43.7              | 50.1   | +1.3                           | 66.7           | Lard and cotton seed oil.                 |
| N | Red, . . . .           | Lard and tallow, . . | Deep color, . . | 43.5              | 49.1   | +0.3                           | 54.7           | Lard and beef tallow and cotton-seed oil. |



# PHOTO-MICROGRAPHS.

Enlargement, 160 diameters.

1



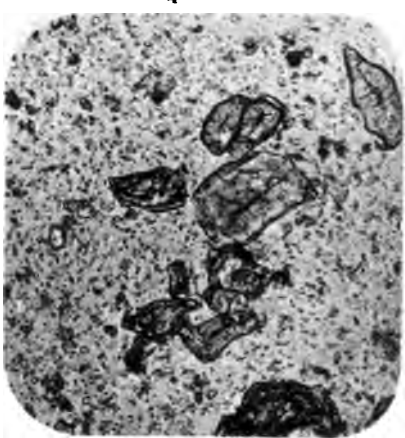
2



3



4



1. Crystals of pure Leaf Lard Stearin.
2. Crystals of pure Back Lard Stearin.
3. Crystals of pure Beef Tallow Stearin.
4. Ground Pepper adulterated with ground Olive Stone.

Samples A, B and C give reactions corresponding to normal pure lard. D, E and F show somewhat high refractometer and iodine numbers but give no direct reaction for cotton-seed oil by the Bechi test. G, although showing low iodine and refractometer numbers, gives no evidence of the presence of tallow by crystallization. In fact, the crystals from this sample proved, under all circumstances, to be most clearly typical of pure lard, — broad and flat plates with obliquely cut ends.

This sample was, in fact, a pure leaf lard. It has been our experience that a stiff, strictly pure leaf lard, which both by its consistency and by its low iodine and refractometer numbers might suggest the presence of beef fat, shows, on crystallization, much more definitely characteristic lard stearin than does a whole hog lard, whose iodine and refractometer numbers are more nearly the normal standard.

In distinction from such a leaf lard, a sample which may have similar consistency and iodine and refractometer numbers, but which is composed of a whole hog lard of a comparatively high iodine number, together with beef fat, gives unmistakable proof of its adulteration by its crystallization.

Fig. 1 shows the crystalline form of pure leaf lard stearin; Fig. 2, of whole hog lard stearin; Fig. 3, of beef tallow stearin.

The adulteration of lard with tallow and cotton-seed oil is wholly unobjectionable as far as the wholesomeness of the compound is concerned. It is objectionable only on the ground of fraud, and is legally permissible provided the mixture is properly labelled.

#### OLIVE OIL.

Forty-two samples proved to be genuine and 9 were found to be adulterated with cotton-seed oil.

#### VINEGAR.

Thirty-two samples were of standard quality and 32 were inferior.

These figures indicate great carelessness as well as fraud in putting up this standard article.

The adulteration of vinegar is chiefly practised outside of Boston, in which city the vigorous enforcement of the law has resulted in the practical suppression of the sale of an inferior article. The report of the inspector of milk and vinegar for 1894, states that, of

938 samples examined, but few failed to conform to the statute requirements, and that dealers in spurious cider vinegar have abandoned Boston as a field of operations. It is to be hoped that a vigorous enforcement of the vinegar law throughout the State will result in driving such dealers out of the Commonwealth.

The definite standards fixed by statute render conviction under the vinegar law comparatively easy.

#### SPICES.

As usual, a large number of ground spices have been examined microscopically and chemically for adulteration.

One thousand and nineteen samples were found pure and 166 adulterated. The extent of adulteration varied from a trace up to 90 per cent.

Spices are very largely adulterated in other States, where a pure food law is not enforced. In this State, when the work of inspection was begun, 65 per cent. of the samples submitted were found to be adulterated. The great and nearly uniform decrease of adulteration of spices since that time may fairly be credited in large part to systematic and persistent public food inspection. The legalized sale of adulterated goods under the name of compounds still continues to a limited extent, with more or less attempt to conceal the real nature of the articles; but there appears to be a healthy and growing demand for guarantees of strict purity among small dealers and consumers.

#### *Allspice.*

Ninety-eight genuine, 4 adulterated. The adulterants found were wheat and nutshells.

#### *Cassia.*

One hundred and forty-six genuine, 2 adulterated. The adulterants found were wheat, corn, nutshells and turmeric.

#### *Cayenne.*

Seventy-three genuine, 34 adulterated. The adulterant found was chiefly corn, but admixtures of wheat, rice, turmeric and salt were also found.

#### *Cloves.*

One hundred and ninety-three genuine, 15 adulterated. The adulterants found were wheat, corn, rice, nutshells, turmeric and clove stems.

*Ginger.*

One hundred and thirty-four genuine, 22 adulterated. The adulterants found were wheat, corn and turmeric. The fancy for deeply coloring this spice with a liberal mixture of turmeric is hardly less frequently met with than in the case of mustard.

*Mace.*

Sixteen genuine.

*Mustard.*

One hundred and twenty-seven genuine, 71 adulterated. The adulterants found were wheat, corn, rice, turmeric, cayenne and gypsum. The "terra alba" was found in one sample to the extent of 21 per cent.

*Nutmeg.*

Six genuine.

*Pepper.*

Two hundred and twenty-six genuine, 17 adulterated. The adulterants found were corn, wheat, rice, ginger, cayenne, grains of paradise, nutshells and buckwheat. Several samples were found to be largely adulterated with woody stone cells, identical with those of the olive stone. Fig. 4 shows the microscopic appearance of one of these samples. This adulteration has been reported found in other localities but it has not been found here before.

## COFFEE.

Seventy-nine genuine, 19 adulterated. The adulterants found were peas and pea hulls, chicory, wheat, straw, sticks, glass and artificial grains made of a roasted wheat mash.

## CREAM OF TARTAR.

Three hundred and sixty-four genuine, 12 adulterated. The adulterants found were starch (wheat and corn), acid phosphate of calcium and gypsum. One sample contained 85 per cent. of the last-named substance.

## HONEY.

Forty-one genuine, 2 adulterated. The adulterant found was glucose syrup.

## MOLASSES.

Two hundred and twelve genuine, 13 adulterated. The adulterant found was glucose syrup.

### MAPLE SUGAR.

Forty genuine, 7 adulterated. The admixture or substitution of a crude brown cane sugar for maple sugar is of frequent occurrence in the spring, when "maple sugar" is to be found in nearly every market or fruit stand, grocer's or confectioner's shop. There is, of course, no valid objection to the sale of a cheap brown sugar moulded into cakes, provided it is not sold as maple sugar and at its comparatively high price.

It is not a difficult matter to distinguish between maple sugar and the "brown sugar" of the grocers' shops by appearance, by odor, particularly when boiled with water, and by taste. Chemically the distinction between the two is facilitated by the fact that the juice of the sugar cane contains from 0.15 to 2 per cent. of albuminous matters, while the sap of the maple tree contains but about 0.01 per cent. of albuminoids.

Notwithstanding the fact that the dilution of the maple sap is greater than that of the cane juice, the fact remains that the ratio of albuminous matters to total solids of the cane juice is greater than that of the maple sap.

The greater sulphur contents of the grocers' brown sugar, which may readily be determined, is apparently due to this cause.

The potash in the ash of sugar from the cane has always been accompanied in our experience by a notable proportion of sodium salt, while the soluble ash of maple sugar has proved nearly pure potash.

### MAPLE SYRUP.

Twenty-seven genuine, 3 adulterated. The adulterant found was glucose syrup.

### TEA.

Eighty-five genuine, 6 inferior. Two samples of compressed tea tablets were examined, with the following widely different results:—

|                                    | A    | B    |
|------------------------------------|------|------|
| Total hot water extract, . . . . . | 19.5 | 54.4 |
| Water, . . . . .                   | 5.05 | 8.7  |
| Insoluble ash, . . . . .           | 4.45 | 2.6  |
| Soluble ash, . . . . .             | 3.45 | 2.8  |
| Theine, . . . . .                  | —    | 2.25 |

### FOOD PRESERVATIVES.

Samples of canned, bottled and dried foods of various kinds have been examined for artificial preservatives. Among those containing borax or boracic acid were samples of shredded codfish, oysters and clam juice.

Notable amounts of salicylic acid were found in many brands of tomato catsup, grape juice, strawberry jam, mince and apple preparations for pies, lager beer and fruit syrups.

A salt sold on the fish wharves as a "fish preservative" proved to be a mixture of common salt and borax. An "oyster preservative" proved to be a mixture of salt and boracic acid.

### EGG FOODS.

Samples of egg foods were examined, with the following results. They purported to be the equivalents in all respects of fresh eggs. A ten-cent package of sample A, for instance, weighing about two ounces, is announced to be equal to twelve eggs, whether of the domestic fowl or not is not specified.

|                                         | A     | B     | C     |
|-----------------------------------------|-------|-------|-------|
| Protein, . . . . .                      | 16.94 | 18.72 | 48.15 |
| Fat, . . . . .                          | 3.43  | 3.40  | 40.56 |
| Water, . . . . .                        | 6.71  | 7.01  | 5.95  |
| Corn starch, salts and coloring matter, | 72.92 | 70.87 | 5.34  |

Another sample was found to contain 29.9 per cent. of sugar.

It will be noted that the composition of sample C corresponds closely to the analysis of dried eggs, which contain of proteid, 54 per cent. ; fat, 40 per cent. ; salts, 5 per cent.

A sample of barberry preserve which had been boiled in a copper kettle was found to contain .003 grams of copper per 100, calculated as the sulphate.

Samples of extract of vanilla were examined by Merck's method. Ten were found to contain from .87 to 2.23 grams of vanillin per litre. Two others were found to contain coumarin.

Samples of fruit jellies were found to be composed of a cheap cider jelly variously modified by neutralizing and artificially coloring and flavoring to represent currant, blackberry, etc.



Thirty-seven samples of granite-ware dishes were examined. They comprised a great variety of articles, a large number of which were for use as cooking utensils. When thus used, particularly with acid contents, the metallic constituents of the glaze are dissolved quite readily. Of these cooking utensils the glaze was found in 23 instances to contain notable quantities of antimony and in 1 instance a small trace of arsenic; 10 contained tin. The glaze of 12 was found to be properly composed of harmless silicates.

A considerable number of samples of a miscellaneous nature have been examined. Among them may be mentioned samples of tea, meat, etc., which were reported to have caused symptoms of poisoning. On examination they gave negative results.

Various pudding preparations, such as "Kustard" and "Desertine," were found to be essentially corn-starch, sweetened, colored and flavored.

A sample of "phosphated gelatine" proved very strongly acid, containing no less than 3.42 per cent. of phosphoric acid.

*Summary of Food Statistics.*

| Foods.                     | Genuine. | Adulterated. | Total. | Per Cent. of Adulteration. |
|----------------------------|----------|--------------|--------|----------------------------|
| Allspice, . . . . .        | 98       | 4            | 102    | 3.9                        |
| Butter, . . . . .          | 186      | 5            | 191    | 2.6                        |
| Canned goods, . . . . .    | 13       | 25           | 38     | 65.8                       |
| Cassia, . . . . .          | 146      | 2            | 148    | 1.3                        |
| Cayenne, . . . . .         | 73       | 34           | 107    | 31.8                       |
| Cheese, . . . . .          | 13       | 0            | 13     | 0.0                        |
| Cloves, . . . . .          | 193      | 15           | 208    | 7.2                        |
| Coffee, . . . . .          | 79       | 19           | 98     | 19.4                       |
| Confectionery, . . . . .   | 61       | 1            | 62     | 1.6                        |
| Cream of tartar, . . . . . | 364      | 12           | 376    | 3.2                        |
| Ginger, . . . . .          | 134      | 22           | 156    | 14.1                       |
| Honey, . . . . .           | 41       | 2            | 43     | 4.6                        |
| Lard, . . . . .            | 17       | 8            | 25     | 32.0                       |
| Mace, . . . . .            | 16       | 0            | 16     | 0.0                        |
| Maple sugar, . . . . .     | 40       | 7            | 47     | 14.9                       |
| Maple syrup, . . . . .     | 27       | 3            | 30     | 10.0                       |
| Miscellaneous, . . . . .   | 143      | 279          | 422    | 66.1                       |
| Molasses, . . . . .        | 212      | 13           | 225    | 5.3                        |
| Mustard, . . . . .         | 127      | 71           | 198    | 35.9                       |
| Nutmeg, . . . . .          | 6        | 0            | 6      | 0.0                        |
| Olive oil, . . . . .       | 42       | 9            | 51     | 17.7                       |
| Pepper, . . . . .          | 226      | 17           | 243    | 7.0                        |
| Syrups, . . . . .          | 5        | 6            | 11     | 54.5                       |
| Tea, . . . . .             | 85       | 6            | 91     | 6.6                        |
| Vinegar, . . . . .         | 32       | 32           | 64     | 50.0                       |
| Total, . . . . .           | 2,379    | 592          | 2,971  | 19.9                       |

## DRUGS.

*Acidum Benzoicum*: 4 standard.

*Acidum Hydrobromicum Dilutum*: 1 standard.

*Acidum Tannicum*: 12 standard.

*Æther*: 5 standard; 8 inferior, containing too much alcohol.

*Alcohol*: 6 standard.

*Aqua Ammoniæ*: 10 standard; 1 inferior, containing too little anhydrous ammonia.

*Aqua Chlori*: 2 inferior; 1 sample contained no trace of chlorine.

*Aqua Destillata*: But little care appears to be taken to supply a good article. The amount of solid matters per 100,000 parts of water may be seen by the following table of results of samples examined:—

*Distilled Water (Parts of Solids per 100,000 of Water).*

|     |     |     |     |      |       |
|-----|-----|-----|-----|------|-------|
| 0.0 | 4.0 | 6.5 | 7.2 | 9.0  | 18.3  |
| 0.0 | 4.2 | 6.5 | 7.5 | 9.0  | 20.0  |
| 0.3 | 4.5 | 6.5 | 7.5 | 9.1  | 38.5  |
| 0.8 | 4.5 | 6.5 | 8.0 | 11.9 | 120.0 |
| 3.0 | 6.2 | 6.6 | 8.5 | 12.8 |       |

*Aqua Hydrogenii Dioxidii*: 2 standard; 2 inferior. The samples which failed to meet the Pharmacopœial requirements contained but 57.5 per cent. and 25 per cent. of the proper amount of peroxide.

*Argenti Nitras*: 7 standard; 1 inferior, containing a sodium salt.

*Bismuthi Subcarbonas*: 1 standard.

*Bismuthi Subnitras*: 7 standard; 2 inferior, containing traces of arsenic.

*Calx Chlorata*: 2 standard; 2 inferior. One of these samples contained but 12 per cent. of available chlorine. The Pharmacopœia demands 35 per cent.

*Cerii Oxalas*: 3 standard.

*Chloroformum*: 8 standard; 1 inferior.

*Creta Præparata*: 3 standard.

*Extractum Glycyrrhizæ*: 2 standard; 23 inferior, containing considerable amounts of corn starch.

*Glycerinum*: 2 standard.

*Iodoformum*: 1 standard.

*Lycopodium*: 1 standard.

*Magnesii Sulphas*: 2 standard.

*Morphinæ Sulphas*: 1 standard.

*Oleum Ætheris*: 1 inferior, consisting chiefly of amyl alcohol.

*Oleum Limonis*: 3 standard; 1 inferior.

*Oleum Morrhuæ*: 5 standard.

*Oleum Ricini*: 10 standard.

*Potassii Iodidum*: 1 standard.

*Pulvis Glycyrrhizæ*: 1 standard.

*Pulvis Glycyrrhizæ Compositus*: 1 inferior.

*Pulvis Opii*: The Pharmacopœia demands from 13 to 15 per cent. of morphine. Samples gave on analysis percentages of morphine as follows:—

|      |      |      |      |      |
|------|------|------|------|------|
| 17.3 | 15.6 | 14.7 | 14.2 | 13.4 |
| 16.5 | 15.0 | 14.6 | 14.1 |      |

*Pulvis Rhei*: 3 standard.

*Spiritus Ætheris Compositus*: 6 standard; 8 inferior, containing little or no heavy oil of ether, upon which the virtue of the drug depends.

*Spiritus Ætheris Nitrosi*: but very few samples showed even an approximation to the Pharmacopœial requirement in contents of ethyl nitrite. This drug cannot be properly kept unless in small, securely sealed bottles, away from the light, and even so it loses its strength in the course of years. Apparently but little care is exercised by druggists to observe these necessary precautions.

*Percentages of the Required Amount of Ethyl Nitrite referred to the Pharmacopœial Standard (100 per cent.) contained in Samples of Spiritus Ætheris Nitrosi.*

|    |    |    |    |   |
|----|----|----|----|---|
| 90 | 69 | 47 | 30 | 8 |
| 90 | 69 | 45 | 28 | 6 |
| 90 | 67 | 44 | 27 | 5 |
| 85 | 66 | 44 | 25 | 5 |
| 83 | 65 | 43 | 25 | 4 |
| 82 | 65 | 42 | 23 | 3 |
| 79 | 63 | 42 | 21 | 3 |
| 77 | 60 | 41 | 20 | 3 |
| 77 | 60 | 41 | 20 | 3 |
| 71 | 60 | 41 | 19 | 2 |
| 70 | 60 | 38 | 19 | 2 |
| 70 | 58 | 36 | 18 | 1 |
| 70 | 56 | 36 | 16 | 1 |
| 70 | 52 | 34 | 11 | 1 |
| 70 | 47 | 33 | 10 |   |

*Spiritus Frumenti*: 1 standard; 6 inferior, as shown below \* :—

| ALCOHOL (BY WEIGHT). | Extract. | ALCOHOL (BY WEIGHT). | Extract. |
|----------------------|----------|----------------------|----------|
| 44.55, . . . . .     | 3.24     | 42.48, . . . . .     | 0.48     |
| 44.24, . . . . .     | 0.74     | 37.22, . . . . .     | 0.16     |
| 42.95, . . . . .     | 1.00     | 37.17, . . . . .     | 0.20     |
| 42.86, . . . . .     | 0.54     |                      |          |

The high extract is due chiefly to added sugar.

*Tinctura Iodi*: 33 standard; 37 inferior, containing too little iodine.

*Tinctura Opii*: the Pharmacopœia demands from 1.3 to 1.5 per cent. of morphine.

\* The Pharmacopœial standard requires 44 to 50 per cent. of alcohol by weight, and not more than 0.25 per cent. of extract.

The samples analyzed contained the following percentages of morphine :—

|      |      |      |      |      |      |
|------|------|------|------|------|------|
| 1.63 | 1.26 | 1.14 | 1.00 | 0.94 | 0.84 |
| 1.50 | 1.25 | 1.11 | 0.98 | 0.94 | 0.82 |
| 1.48 | 1.23 | 1.08 | 0.98 | 0.93 | 0.78 |
| 1.43 | 1.23 | 1.08 | 0.97 | 0.91 | 0.76 |
| 1.37 | 1.23 | 1.07 | 0.96 | 0.90 | 0.68 |
| 1.35 | 1.18 | 1.05 | 0.96 | 0.89 | 0.67 |
| 1.35 | 1.16 | 1.04 | 0.96 | 0.89 | 0.53 |
| 1.28 | 1.15 | 1.03 | 0.95 | 0.88 | 0.43 |
| 1.27 | 1.15 | 1.00 | 0.95 | 0.88 |      |
| 1.26 | 1.15 | 1.00 | 0.95 | 0.84 |      |

*Sapo*: The Pharmacopœia prescribes a limit of 36 per cent. of water and tests by which an excess of free alkali and the presence of animal fats, which are prohibited, may be determined. The agreement of the samples examined with these requirements may be seen from the following table :—

| SAMPLE.       |  |  |  |  |  |  | Water. | Excess of Free Alkali. | Presence of Animal Fats by the Pharmacopœial Test. |
|---------------|--|--|--|--|--|--|--------|------------------------|----------------------------------------------------|
| 1, . . . . .  |  |  |  |  |  |  | 7.4    | Slight excess.         | None.                                              |
| 2, . . . . .  |  |  |  |  |  |  | 3.6    | None.                  | None.                                              |
| 3, . . . . .  |  |  |  |  |  |  | 4.1    | Much excess.           | None.                                              |
| 4, . . . . .  |  |  |  |  |  |  | 10.8   | Much excess.           | None.                                              |
| 5, . . . . .  |  |  |  |  |  |  | 7.1    | None.                  | Present.                                           |
| 6, . . . . .  |  |  |  |  |  |  | 9.0    | None.                  | Present.                                           |
| 7, . . . . .  |  |  |  |  |  |  | 7.1    | None.                  | Present.                                           |
| 8, . . . . .  |  |  |  |  |  |  | 5.9    | None.                  | Present.                                           |
| 9, . . . . .  |  |  |  |  |  |  | 9.8    | Much excess.           | Present.                                           |
| 10, . . . . . |  |  |  |  |  |  | 6.4    | Much excess.           | Present.                                           |
| 11, . . . . . |  |  |  |  |  |  | 6.4    | Much excess.           | Present.                                           |
| 12, . . . . . |  |  |  |  |  |  | 5.0    | None.                  | Present.                                           |
| 13, . . . . . |  |  |  |  |  |  | 9.4    | None.                  | None.                                              |
| 14, . . . . . |  |  |  |  |  |  | 9.1    | None.                  | None.                                              |
| 15, . . . . . |  |  |  |  |  |  | 5.4    | None.                  | Present.                                           |
| 16, . . . . . |  |  |  |  |  |  | 7.4    | Slight excess.         | Present.                                           |
| 17, . . . . . |  |  |  |  |  |  | 11.2   | None.                  | None.                                              |
| 18, . . . . . |  |  |  |  |  |  | 6.2    | None.                  | None.                                              |
| 19, . . . . . |  |  |  |  |  |  | 15.0   | Much excess.           | None.                                              |
| 20, . . . . . |  |  |  |  |  |  | 6.7    | Slight excess.         | Present.                                           |
| 21, . . . . . |  |  |  |  |  |  | 14.8   | Slight excess.         | Present.                                           |
| 22, . . . . . |  |  |  |  |  |  | 7.0    | None.                  | Present.                                           |
| 23, . . . . . |  |  |  |  |  |  | 8.3    | Much excess.           | Present.                                           |
| 24, . . . . . |  |  |  |  |  |  | 27.0   | Slight excess.         | Present.                                           |
| 25, . . . . . |  |  |  |  |  |  | 5.5    | Slight excess.         | Present.                                           |
| 26, . . . . . |  |  |  |  |  |  | 6.0    | Slight excess.         | Present.                                           |
| 27, . . . . . |  |  |  |  |  |  | 9.7    | Much excess.           | Present.                                           |
| 28, . . . . . |  |  |  |  |  |  | 7.5    | Slight excess.         | Present.                                           |
| 29, . . . . . |  |  |  |  |  |  | 10.6   | Slight excess.         | Present.                                           |
| 30, . . . . . |  |  |  |  |  |  | 4.9    | Much excess.           | None.                                              |
| 31, . . . . . |  |  |  |  |  |  | 2.4    | None.                  | Present.                                           |
| 32, . . . . . |  |  |  |  |  |  | 12.2   | None.                  | None.                                              |
| 33, . . . . . |  |  |  |  |  |  | 5.8    | None.                  | None.                                              |

*Unguentum Hydrargyri*: the Pharmacopœia demands 50 per cent. of mercury. The percentages of mercury found in the samples examined were as follows :—

|    |    |    |    |     |
|----|----|----|----|-----|
| 60 | 51 | 35 | 32 | 23  |
| 57 | 49 | 34 | 31 | 20  |
| 52 | 48 | 33 | 30 | 20  |
| 52 | 47 | 33 | 30 | 8.9 |

A sample of unguentum zinci oxidi was found to be composed of 10.5 per cent. of oxide of zinc mixed with plain lard. The Pharmacopœia demands 20 per cent. of the zinc salt to be mixed with benzoated lard.

*Vinum Album*: 12 samples, all inferior, as shown by the following figures :—

| ALCOHOL (BY WEIGHT). | Extract. | ALCOHOL (BY WEIGHT). | Extract. |
|----------------------|----------|----------------------|----------|
| 19.17, . . . . .     | 4.70     | 15.17, . . . . .     | 5.90     |
| 18.85, . . . . .     | 5.14     | 15.06, . . . . .     | 6.00     |
| 17.15, . . . . .     | 4.14     | 14.64, . . . . .     | 7.29     |
| 17.00, . . . . .     | 6.46     | 13.54, . . . . .     | 7.96     |
| 15.47, . . . . .     | 6.00     | 13.41, . . . . .     | 7.00     |
| 15.45, . . . . .     | 7.50     | 13.03, . . . . .     | 6.00     |

The Pharmacopœia demands 10 to 14 per cent. of alcohol and 1.5 to 3 per cent. of solid extract. The high extract was due chiefly to added sugar.

*Vinum Rubrum*: 12 samples, all inferior, as follows :—

| ALCOHOL (BY WEIGHT). | Extract. | ALCOHOL (BY WEIGHT). | Extract. |
|----------------------|----------|----------------------|----------|
| 18.08, . . . . .     | 11.44    | 15.00, . . . . .     | 12.20    |
| 17.00, . . . . .     | 10.15    | 14.91, . . . . .     | 13.76    |
| 16.92, . . . . .     | 11.49    | 14.09, . . . . .     | 15.03    |
| 16.62, . . . . .     | 13.59    | 13.69, . . . . .     | 10.42    |
| 16.15, . . . . .     | 13.04    | 12.62, . . . . .     | 10.50    |
| 15.17, . . . . .     | 10.09    | 11.31, . . . . .     | 11.99    |

The Pharmacopœia demands 10 to 14 per cent. of alcohol and 1.6 to 3.5 per cent. of solid extract. As a rule port wine contains a large amount of added sugar.

Several samples of Mme. Ruppert's face bleach have been examined and all were found to contain corrosive sublimate to the extent of about 27 grains per 8 ounce bottle. The bottles were provided with the poison labels required by statute, but they were pasted on the bottoms of the bottles, where they are fairly certain to escape the notice of the average purchaser.

A sample of "Perry's Freckle Lotion" was found to contain 39 grains of the same poison per 8 ounce bottle.

A "Recamier Balm" was found to consist essentially of zinc oxide suspended in water with a trace of corrosive sublimate.

An "Excelsior Hair Tonic" consisted essentially of a bay rum containing quinine.

A sample of "Pulmonine" was found to contain 16 per cent. of alcohol by volume.

A "Coca-Kola" preparation contained caffein, cocain, sugar and tartaric acid.

"Hunyadi Granules" were found to consist essentially of tartaric acid and bicarbonate of soda.

"Vichi Granules" were of the same composition.

*Summary.*

|                          | Genuine. | Adulterated. | Total. |
|--------------------------|----------|--------------|--------|
| Milk, . . . . .          | 1,720    | 1,829        | 3,549  |
| Food not milk, . . . . . | 2,379    | 592          | 2,971  |
| Drugs, . . . . .         | 212      | 332          | 544    |
| Total, . . . . .         | 4,311    | 2,753        | 7,064  |

Respectfully submitted,

CHARLES P. WORCESTER.

## PROFESSOR GOESSMANN'S REPORT.

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The whole number of samples of milk obtained and examined in the four western counties during the year was 245, of which number 60, or 24.5 per cent., proved to be below the standard.

It would be fair, however, to exclude from this number 12 samples which were obtained in West Deerfield from suspected producers, of which number 11 were found to be below the standard. Three of this number were taken from one dairy, and the results of analysis showed the following figures: 8.69, 7.44 and 6.66 per cent. of total solids respectively, the latter being the lowest taken during the year, and representing about 50 per cent. of added water. This man was promptly convicted and fined.

With these exceptions the percentage of adulterated samples in milk taken under the usual conditions of sale was 21, or a trifle less than that of 1894.

The ratio of adulteration for the past ten years shows a fairly uniform quality, the figures being as follows:—

| YEAR.           | Per Cent. of<br>Adulteration. | YEAR.           | Per Cent. of<br>Adulteration. |
|-----------------|-------------------------------|-----------------|-------------------------------|
| 1886, . . . . . | 20.0                          | 1891, . . . . . | 18.4                          |
| 1887, . . . . . | 10.5                          | 1892, . . . . . | 19.8                          |
| 1888, . . . . . | 15.7                          | 1893, . . . . . | 20.3                          |
| 1889, . . . . . | 17.7                          | 1894, . . . . . | 21.3                          |
| 1890, . . . . . | 22.6                          | 1895, . . . . . | 21.0                          |

Mean ratio, ten years, 18.9 per cent.

These figures are the result of examination of 2,407 samples, of which 456 were below standard.



The following summary embraces the samples of milk obtained during the year in cities and towns west of Worcester County.

The results of analyses were as follows :—

|                              |   |   |   |   |   |   |   |   |      |
|------------------------------|---|---|---|---|---|---|---|---|------|
| Whole number examined,       | . | . | . | . | . | . | . | . | 245  |
| Number above standard,       | . | . | . | . | . | . | . | . | 185  |
| Number below standard,       | . | . | . | . | . | . | . | . | 60   |
| Percentage below standard,   | . | . | . | . | . | . | . | . | 24.5 |
| Number samples skimmed milk, | . | . | . | . | . | . | . | . | 11   |

*Chicopee.*

|                                      |      |
|--------------------------------------|------|
| Number of samples, . . . . .         | 22   |
| Number above standard, . . . . .     | 18   |
| Number below standard, . . . . .     | 4    |
| Percentage below standard, . . . . . | 18.2 |
| Skimmed milk, . . . . .              | 3    |

*Holyoke.*

|                                      |      |
|--------------------------------------|------|
| Number of samples, . . . . .         | 58   |
| Number above standard, . . . . .     | 47   |
| Number below standard, . . . . .     | 11   |
| Percentage below standard, . . . . . | 19.0 |
| Skimmed milk, . . . . .              | 5    |

*Northampton.*

|                                      |    |
|--------------------------------------|----|
| Number of samples, . . . . .         | 17 |
| Number above standard, . . . . .     | 17 |
| Number below standard, . . . . .     | 0  |
| Percentage below standard, . . . . . | 0  |
| Skimmed milk, . . . . .              | 2  |

*Pittsfield.*

|                                      |      |
|--------------------------------------|------|
| Number of samples, . . . . .         | 16   |
| Number above standard, . . . . .     | 13   |
| Number below standard, . . . . .     | 3    |
| Percentage below standard, . . . . . | 18.8 |
| Skimmed milk, . . . . .              |      |

*Springfield.*

|                                      |      |
|--------------------------------------|------|
| Number of samples, . . . . .         | 44   |
| Number above standard, . . . . .     | 33   |
| Number below standard, . . . . .     | 11   |
| Percentage below standard, . . . . . | 25.0 |
| Skimmed milk, . . . . .              | 1    |

The results in the towns were as follows : —

|                           | Total. | Above<br>Standard. | Below<br>Standard. | Percentage<br>Below<br>Standard. |
|---------------------------|--------|--------------------|--------------------|----------------------------------|
| Greenfield, . . . . .     | 15     | 10                 | 5                  | —                                |
| North Adams, . . . . .    | 14     | 12                 | 2                  | —                                |
| South Hadley, . . . . .   | 1      | 1                  | —                  | —                                |
| Ware, . . . . .           | 32     | 24                 | 8                  | —                                |
| West Deerfield, . . . . . | 12     | 1                  | 11                 | —                                |
| Westfield, . . . . .      | 14     | 9                  | 5                  | —                                |
|                           | 88     | 57                 | 31                 | 35.2                             |

C. A. GOESSMANN,

*Analyst.*

AMHERST, MASS.



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# REPORT

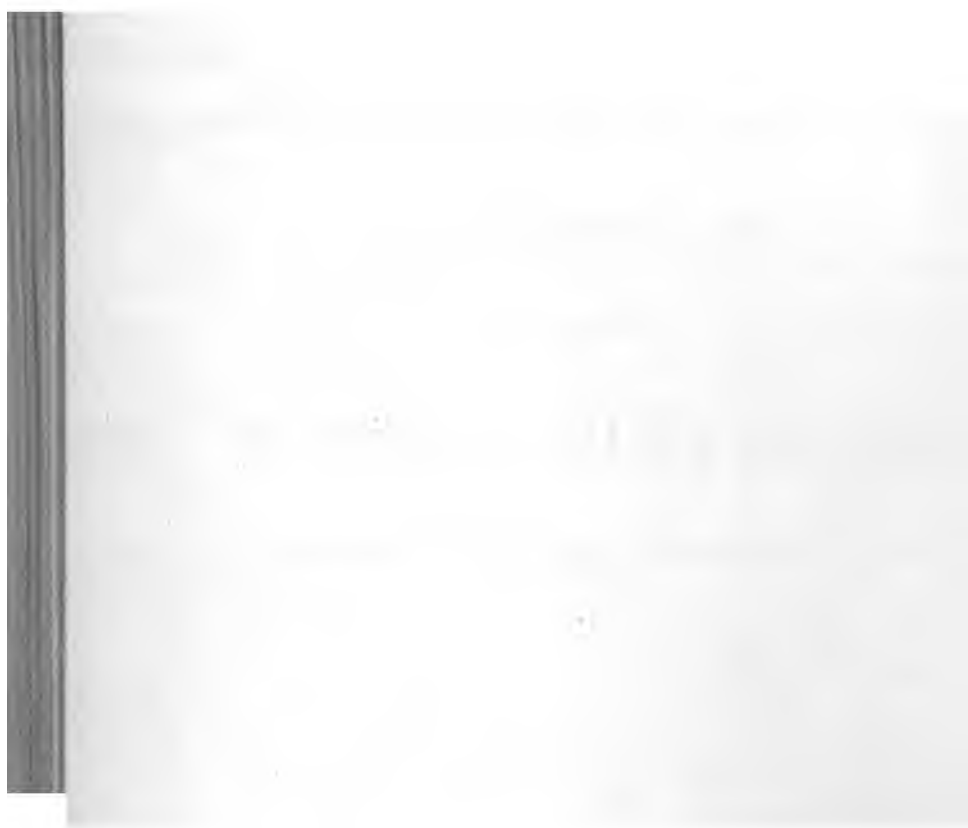
UPON THE

## PRODUCTION AND USE OF ANTITOXIN.

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[687]



## REPORT UPON THE PRODUCTION AND USE OF ANTITOXIN.

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In the last annual report of the State Board of Health (p. cvii) brief reference was made to the work of the Board which had been undertaken for the purpose of providing a supply of antitoxin for general use in reducing as far as possible the fatality from diphtheria in Massachusetts. The saving of human life, which had been claimed by Dr. Roux in his report upon this subject at the International Congress of Hygiene at Buda Pesth in 1894, and the similar results elsewhere attained on both sides of the Atlantic, were apparently demonstrated in so convincing a manner as to warrant the adoption of antitoxin both as a therapeutic and preventive remedy for general use. Hence the Board, acting under the provisions of the statutes requiring it to "take cognizance of the interests of health and life among the citizens of the Commonwealth," and believing it possible to reduce the fatality and consequently the death rate from diphtheria, not only by recommending the use of this measure for the purpose, but also by providing the material for such use, established in October, 1894, a laboratory for the production of antitoxin, and appointed Dr. J. L. Goodale of Cambridge to superintend the work of its preparation. The scope of this laboratory was soon afterward enlarged, so as to embrace general bacteriological work. Dr. Goodale entered upon the work with enthusiasm, and the successful operation which was thus secured was largely due to his earnest devotion to this work. Since, however, it soon became necessary to provide for additional bacteriological work on a larger scale, Dr. Theobald Smith, chief of the Division of Pathology of the Bureau of Animal Industry at Washington, D. C., was appointed pathologist of the Board, to take charge of this department.

After the necessary preliminary steps had been taken toward securing a continuous supply of antitoxin (providing the stables, purchasing the horses, preparing and injecting the toxine, etc.), the first quantity of antitoxin of a sufficient strength for use in the preventive treatment of diphtheria was offered for distribution in March, 1895, and the following circular was then published and distributed to boards of health throughout the State:—

## COMMONWEALTH OF MASSACHUSETTS.

## DIPHThERIA ANTITOXIN.

*[A Circular of the State Board of Health.]*

STATE HOUSE, BOSTON, March 25, 1895.

The investigations of Behring and Roux with reference to the value of serum-therapy in the treatment of diphtheria, and the later experience of its use in diminishing the mortality from this disease, are widely known and fully understood.

The State Board of Health, in accordance with its organic purpose as defined in the statutes, having in view the "interests of health and life among the citizens of the Commonwealth," and recognizing the value to the people of any agent which will measurably prevent the ravages of a disease capable of destroying more than a thousand of lives annually in Massachusetts and of causing suffering which cannot be expressed numerically, has prepared a supply of antitoxin, for the benefit, primarily, of such communities in this State as find it difficult or impracticable for any reason to supply themselves with the new agent from reliable sources.

Great care has been exercised in the preparation of this supply to fulfil the most exacting technical requirements for obtaining a pure and trustworthy product, and the tests of its strength have shown satisfactory results.

The Board does not propose to offer it for sale, but its gratuitous distribution will be under strict conditions designed to prevent abuse and waste and to obtain the most beneficial fruits. Each bottle is marked with a number and the date of the preparation of its contents. No antitoxin will be issued except upon a pledge that a full statement of the observed effects of its use will be returned to the Board at the termination of the case. In all instances possible a bacterial diagnosis will be insisted upon. The Board desires to emphasize the importance of using such appliances only as are adapted to the proper administration of the remedy, of remembering that experience has demonstrated that antitoxin is most useful in the earliest stages of a diphtheritic attack, and of realizing that trained medical skill is required to administer it successfully.

A blank form for the report and a detailed statement of instructions as to methods will accompany each bottle of the antitoxin serum.

For the needs of persons living within twenty-five miles of Boston, it will be required, for the present, that personal application at the office of the Board shall be made by the attending physician in the diphtheria case, or by some person authorized by him. For the convenience of more distant parts of the State, local agencies at public hospitals or municipal health offices will probably be established by the Board in accessible centres.

The office of the Board (Room 141, State House Extension) is open each week-day, except Saturday, from 9 A.M. to 5 P.M., and on Saturday from 9 A.M. to 2 P.M.

SAM'L W. ABBOTT, *Secretary.*

as a matter of convenience, therefore, the time embraced in this report is made to include the full year ending with March 31, 1896, as the general distribution of antitoxin by the Board may be considered as beginning about one year earlier than that date, although no vials were issued during the last week of March, 1895.

Diphtheria usually prevails with considerable severity in the spring months, but not so severely as in winter; and, since the lack of the same character proposed for the city of Boston was not in operation, the demand for antitoxin which came, not only from cities and towns but also from the newly equipped contagious disease hospital of Boston, for several weeks required all that the Board could supply. With the exception, however, of a few days in midsummer, it was enabled to supply all that was demanded.

The compiler recognizes, at the outset, the extreme difficulties attending the analysis of the results of the use of antitoxin, and therefore availed himself of the recognized authorities upon the subject, and has followed their methods as closely as possible in preparing these results.

Rarely any subject in medicine, requiring careful analysis, presents so great a multiplicity of limiting conditions and circumstances.

For example, the diagnosis of the disease, the age and sex of the patient, the severity of the attack, the time elapsing before the employment of antitoxin, the previous condition of the patient, the quantity and strength of the serum employed, the existence of complications and of surgical operations performed upon the patient, each and all of these conditions affect the result, and some of them to a very important degree.

In Dr. Welch's admirable monograph on the "Treatment of diphtheria by antitoxin" a summary is presented which gives the results of the use of antitoxin in 7,166 cases of diphtheria. This consists of the experience of 82 observers, widely separated, in different parts of the world, including France, Germany, Austria, Prussia, Switzerland, England and America. The deaths were 9, or 17.3 per cent. of the whole number of cases. It was stated, from observations recorded by these same authorities, that the mean fatality in the same places and under similar conditions, before the introduction of antitoxin, was 42.1 per cent. The foregoing figures are very largely quoted from hospital practice wherein the fatality is invariably and for obvious reasons greater than that which occurs in general private practice.



The following figures give the fatality from diphtheria and croup in general practice in England and in Massachusetts, and, being the results of observation in over 84,000 cases, may be taken as fairly correct.

That of England for the five years (1890-94) was 24.4 per cent., being the ratio of 17,318 deaths to 71,003 reported cases; and that of Massachusetts for 1891-94 was 28.3 per cent., being the ratio of 3,768 deaths to 13,332 notified cases.

The actual fatality in Massachusetts was probably slightly less than 28.3, in consequence of the fact that the registered deaths from diphtheria may be regarded as nearly correct, while the number of reported cases must be regarded as less than the actual number, on account of failure or neglect to report in some instances, especially in small towns, where no well-organized boards of health exist.

The claim has been made that the decrease in fatality in diphtheria is not due to the use of antitoxin, but to improved modes of diagnosis, by means of bacterial cultures. On the other hand, it is also true that before the introduction of more accurate means of diagnosis it was a quite common practice with some physicians to report all cases of sore throat as diphtheria, so that these two facts must be considered together.

From all the evidence that we can obtain from recorded observations, we are inclined to believe that 25 per cent. should be considered as being about the average fatality for diphtheria in Massachusetts during the five years previous to the introduction of antitoxin. During the severe epidemic years from 1875 to 1882, it is probable that the fatality was somewhat greater.

The fatality in hospital practice may be considered as at least 50 per cent. greater than that of general practice, since mild cases do not generally reach the hospital, and many of those who are sent for hospital treatment are beyond all prospect of recovery at the time of admission.

The limited character of this report, that is to say, the defect due to the fact that a very considerable portion of the antitoxin issued is unaccounted for by any returns from those who used it, is due to several causes. First, the distribution of the material over a large extent of territory (in some instances one hundred and fifty miles or more from the base of supply); second, its use in many instances in small towns in which the physicians were unused to the work of making returns; third, about two hundred packages were

or immunizing; fourth, a small allowance must be made for  
 ges of bottles and for packages remaining unused on deposit  
 ards of health.

first bottles of serum, issued near the close of March, 1895,  
 ed twenty cubic centimeters of serum each, and for several  
 this quantity was put into each vial; but, as the strength of  
 um was increased, the size of the receptacle was diminished,  
 fifteen cubic centimeters and finally to ten cubic centimeters,  
 er size being at present employed exclusively, for the pur-  
 f containing the quantity of serum most convenient for im-  
 e use, since it is essential to its proper employment that no  
 of the contents should be reserved for future use after a  
 has once been opened, unless such reserved portion be used  
 a few hours (twenty-four hours at the extreme limit) after-

total amount of antitoxin serum issued by the Board during  
 ar ending March 31, 1896, was 1,724 bottles, containing in  
 ut 30,000 cubic centimeters of serum, the strength of which  
 from sixty to one hundred units in each cubic centimeter.  
 serum was distributed to the cities and towns as follows:—

*Number of Bottles of Diphtheria Antitoxin distributed to the Different  
 Towns and Cities from March 23, 1895, to April 1, 1896.*

| CITY OR TOWN.               | Number<br>Bottles. | CITY OR TOWN.                   | Number<br>Bottles. |
|-----------------------------|--------------------|---------------------------------|--------------------|
| . . . . . 45                | 368                | Worcester, . . . . .            | 101                |
| ston, . . . . . 4           |                    | Lynn, . . . . .                 | 83                 |
| oston, . . . . . 23         |                    | Woburn:                         |                    |
| . Plain, . . . . . 1        |                    | Woburn, . . . . . 74            | 75                 |
| town, . . . . . 1           |                    | North Woburn, . . . . . 1       |                    |
| y, . . . . . 8              |                    | Newton:                         |                    |
| ster, . . . . . 9           | 238                | Newton, . . . . . 10            | 71                 |
| spital, . . . . . 195       |                    | West Newton, . . . . . 2        |                    |
| st's Hospital, . . . . . 81 |                    | Newton Upper Falls, . . . . . 1 |                    |
| ussetts General Hospital, 1 |                    | City Hospital, . . . . . 58     |                    |
| e:                          |                    | Brookline, . . . . .            | 70                 |
| lge, . . . . . 82           |                    | Waltham, . . . . .              | 56                 |
| lgeport, . . . . . 41       | 238                | Everett, . . . . .              | 47                 |
| spital, . . . . . 146       |                    | Malden, . . . . .               | 43                 |
| ambridge, . . . . . 19      |                    | Taunton, . . . . .              | 42                 |
|                             |                    | Stoneham, . . . . .             | 34                 |

*Showing Number of Bottles of Diphtheria Antitoxin distributed to the Different Towns and Cities from March 23, 1895, to April 1, 1896 — Continued.*

| CITY OR TOWN.                 | Number Bottles. | CITY OR TOWN.                  | Number Bottles. |
|-------------------------------|-----------------|--------------------------------|-----------------|
| Winchester, . . . . .         | 32              | Hudson, . . . . .              | 5               |
| Beverly, . . . . .            | 26              | Westborough, . . . . .         | 5               |
| Somerville:                   |                 | Bedford, . . . . .             | 4               |
| Somerville, . . . . . 21      | } 25            | Lee, . . . . .                 | 4               |
| West Somerville, . . . . . 4  |                 | Rockland, . . . . .            | 4               |
| Haverhill, . . . . .          | 22              | Watertown, . . . . .           | 4               |
| Lowell, . . . . .             | 19              | Melrose:                       |                 |
| Pittsfield, . . . . .         | 17              | Melrose, . . . . . 3           | } 4             |
| Springfield, . . . . .        | 17              | Melrose Highlands, . . . . . 1 |                 |
| Milford, . . . . .            | 16              | Palmer:                        |                 |
| Abington:                     |                 | Palmer, . . . . . 2            | } 4             |
| Abington, . . . . . 12        | } 16            | Three Rivers, . . . . . 2      |                 |
| North Abington, . . . . . 4   |                 | Hardwick, . . . . .            | 3               |
| Amesbury, . . . . .           | 15              | Ludlow, . . . . .              | 3               |
| Dalton, . . . . .             | 15              | North Attleborough, . . . . .  | 3               |
| Arlington, . . . . .          | 14              | Southampton, . . . . .         | 3               |
| Braintree:                    |                 | Ware, . . . . .                | 3               |
| Braintree, . . . . . 4        | } 14            | Warren, . . . . .              | 3               |
| South Braintree, . . . . . 10 |                 | Concord, . . . . .             | 2               |
| Fitchburg, . . . . .          | 13              | Brockton:                      |                 |
| Clinton, . . . . .            | 12              | Brockton, . . . . . 1          | } 2             |
| North Adams, . . . . .        | 11              | Campello, . . . . . 1          |                 |
| Randolph, . . . . .           | 11              | Ashburnham, . . . . .          | 2               |
| Weymouth:                     |                 | Lenox, . . . . .               | 2               |
| Weymouth, . . . . . 2         | } 9             | Holbrook, . . . . .            | 2               |
| North Weymouth, . . . . . 3   |                 | Monson, . . . . .              | 2               |
| East Weymouth, . . . . . 4    |                 | Norwood, . . . . .             | 2               |
| Sharon, . . . . .             | 8               | Salem, . . . . .               | 2               |
| Hyde Park, . . . . .          | 7               | Saugus, . . . . .              | 2               |
| Marlborough, . . . . .        | 7               | Boylston, . . . . .            | 1               |
| Quincy:                       |                 | Brimfield, . . . . .           | 1               |
| Quincy, . . . . . 5           | } 7             | Cummington, . . . . .          | 1               |
| West Quincy, . . . . . 2      |                 | Canton, . . . . .              | 1               |
| Westfield, . . . . .          | 7               | Danvers, . . . . .             | 1               |
| Foxborough, . . . . .         | 6               | Dedham, . . . . .              | 1               |
| Northborough, . . . . .       | 6               | Georgetown, . . . . .          | 1               |
| Fall River, . . . . .         | 5               | Hanson, . . . . .              | 1               |

*Following Number of Bottles of Diphtheria Antitoxin distributed to the Different Towns and Cities from March 23, 1895, to April 1, 1896 — Concluded.*

| CITY OR TOWN.        | Number<br>Bottles | CITY OR TOWN.               | Number<br>Bottles. |
|----------------------|-------------------|-----------------------------|--------------------|
| Worcester, . . . . . | 1                 | Sutton, . . . . .           | 1                  |
| Worcester, . . . . . | 1                 | Wakefield, . . . . .        | 1                  |
| Worcester, . . . . . | 1                 | Wellesley, . . . . .        | 1                  |
| Worcester, . . . . . | 1                 | Place not stated, . . . . . | 2                  |
| Worcester, . . . . . | 1                 | Total, . . . . .            | 1,724              |
| Worcester, . . . . . | 1                 |                             |                    |

It was distributed to the following hospitals, in accordance with demand from them :—

In Boston, the City Hospital for Contagious Diseases, the Children's Hospital, the Massachusetts General Hospital; in Cambridge, the Cambridge Hospital (contagious ward); in Newton, to the Newton Hospital; in Lynn, to the Lynn Hospital for Contagious Diseases; in Waltham, to the Waltham Hospital; in Brookline, to the Brookline Hospital for Contagious Diseases; in Pittsfield, to the House of Mercy; in Westborough, to the Lyman School for Boys.

The board of health of Worcester and the House of Mercy at Pittsfield lent their efficient co-operation by acting as distributing centres for the smaller neighboring towns.

In order that the results of the use of the serum issued by the Board might be known as fully as possible, a blank form was prepared and issued with each package of antitoxin, of which the following is a copy :—

MASSACHUSETTS STATE BOARD OF HEALTH.

BLANK FOR RECORDING TREATMENT WITH DIPHTHERIA ANTITOXIN.

Name of attending physician,

Address,

Name of patient,

Address,

Age,

Results of bacteriological examination,

Physical condition of patient previous to present illness,

Date when symptoms first appeared,

Condition at time of first injection of antitoxin (underline symptoms mentioned below which are present).

- LOCAL.** { *Nose*: coryza, purulent discharge, false membrane.  
*Pharynx*: state distribution of false membrane,  
*Larynx*: hoarseness, cough, dyspnoea, stenosis.  
*Cervical glands*: changes,  
*General appearance*: degree of prostration, etc.,  
*Lungs*: note character and extent of involvement,  
**GENERAL.** { *Heart*: note strength of action and any abnormalities,  
*Kidneys*: give analysis of urine,  
 Other complications,

The subsequent history is to be noted on the chart on the next page.

This blank should be properly filled and returned to the office of the Board, Room 142, State House, in each and every case in which antitoxin furnished by the Board is employed.

| Date.<br>Give Hour<br>of<br>Observation. | Temperature. | Pulse. | Respiration. | Changes in<br>Local<br>Condition. | Changes in<br>General<br>Condition. | Amount<br>and Source<br>of<br>Antitoxin<br>Injected. | NOTE. — Phenomena at Site of<br>Inoculation. Complica-<br>tions. Sequelæ.<br>Give Local and General Medica-<br>tion Employed. |
|------------------------------------------|--------------|--------|--------------|-----------------------------------|-------------------------------------|------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| A. M.                                    |              |        |              |                                   |                                     |                                                      |                                                                                                                               |
| P. M.                                    |              |        |              |                                   |                                     |                                                      |                                                                                                                               |
| A. M.                                    |              |        |              |                                   |                                     |                                                      |                                                                                                                               |
| P. M.                                    |              |        |              |                                   |                                     |                                                      |                                                                                                                               |
| A. M.                                    |              |        |              |                                   |                                     |                                                      |                                                                                                                               |
| P. M.                                    |              |        |              |                                   |                                     |                                                      |                                                                                                                               |
| A. M.                                    |              |        |              |                                   |                                     |                                                      |                                                                                                                               |
| P. M.                                    |              |        |              |                                   |                                     |                                                      |                                                                                                                               |

The importance of returning these blanks properly filled with the items relative to each case does not appear to have been fully appreciated by the physicians who have used the antitoxin in different parts of the State. Our knowledge of the effect of any new therapeutic agent must be the result of observation, and it is very desirable that the observations of physicians in private practice should be fully recorded, since very much of the published results from the use of antitoxin are derived from hospital reports. Hence the Board would respectfully urge all physicians who are in the habit of obtaining the antitoxin prepared and furnished by the Board to report upon the same in as full a manner as possible.

The whole number of individual reports received by the Board from all sources for the year ending March 31, 1896, was 562. It is impossible to state the exact number treated with the antitoxin furnished by the Board during the time stated. It is probably not far from 1,000.

In order to form a just estimate of the value of this agent from the experiences recorded, it will be necessary to classify the returns,

and to separate those where a bacterial diagnosis was made by culture from those where no such examination was made. Of the former there were 289 returns and of the latter there were 273.

*Cases in which a Bacterial Examination was made.*—It is desirable to divide this class into two groups,—those in which the diagnosis was positive and those in which it was negative. There were 262 cases in which the diagnosis was positive, as shown by cultures taken from the throat, and of this number 36 died, or 13.7 per cent. of the whole number of positive cases.

*Sex.*—The number of males was 125, and the deaths of these were 18, or 14.4 per cent. The number of females was 135, and the deaths of these were 17, or 12.6 per cent. The sex of two was not stated.

*Ages.*—By ages the numbers and the deaths were as follows:—

| AGE PERIODS.                 | Cases. | Deaths. | Fatality<br>(Per Cent.). |
|------------------------------|--------|---------|--------------------------|
| From 0 to 2 years, . . . . . | 30     | 9       | 30.0                     |
| " 2 to 5 " . . . . .         | 71     | 16      | 22.5                     |
| " 5 to 10 " . . . . .        | 91     | 9       | 9.9                      |
| Over 10 years, . . . . .     | 67     | 2       | 3.0                      |
| Age unknown, . . . . .       | 8      | 0       | 0.0                      |
| Totals, . . . . .            | 262    | 36      | —                        |
| Mean, . . . . .              | —      | —       | 13.7                     |

*Day of Illness when Antitoxin was first administered.*

|                                 |                                   |
|---------------------------------|-----------------------------------|
| Fatality, . . . . . 1st day, 0. | Fatality, . . . . . 5th day, 22.2 |
| " . . . . . 2d " 9.7            | " . . . . . 6th " 20.0            |
| " . . . . . 3d " 8.7            | " . . . . . 7th " 33.3            |
| " . . . . . 4th " 15.4          |                                   |

In many instances the day of administration was not stated. The foregoing table relates only to those cases in which the day of illness is noted on which the antitoxin was used.

*Negative Cases.*—There were also 27 cases in which the bacterial examination gave either a negative or a doubtful result (23 negative and 4 doubtful), and the deaths among these were 5, or 18.5 per cent.

The fatality of positive cases treated in hospitals was as follows: cases, 85; deaths, 15, = 17.6 per cent.; in private practice, cases, 10; deaths, 21, = 11.9 per cent.

*Cases in which no Bacterial Examination was made.*—In the second series, in which no bacterial examination was made, the total number of cases in which antitoxin was reported as having been employed was 273, and the number of deaths recorded was 32, or 11.7 per cent.

*Sex.*—The number of males treated was 123, and the deaths of these were 14, or 11.4 per cent. The number of females was 143, and the deaths of these were 17, or 11.9 per cent.

*Ages.*—Of children under 2 years of age, 10 were treated, and the deaths of these were 5, or 50 per cent. Of children from 2 to 5 years of age there were 71 cases and 10 deaths, or 14.1 per cent. Of children from 5 to 10 years old there were 104, with 13 deaths, or 12.5 per cent. Of persons over 10 years of age there were 75, with 2 deaths, a fatality of 2.7 per cent. Of persons of unknown age there were 13, with 2 deaths.

The following record presents a brief statement of each of the fatal cases which occurred among those which had been determined by bacterial examination to be cases of diphtheria:—

#### DEATHS.

##### *Private Practice.*

1. Male, one year (February, 1896). Marked prostration, membrane general in pharynx. Improvement for ten days, followed by paralysis of throat, hoarseness, cough and dyspnoea, considerable swelling of glands of neck, marked prostration. Ten cubic centimeters of antitoxin, time not stated.

2. Male, three years (January, 1896). Treatment begun fourth day of illness. Face flushed, membrane on right tonsil and in nares; detaching and throat clear on sixth day; hoarseness, cough and dyspnoea; glands of neck swollen on right side; heart and urine normal. Death on seventh day. Antitoxin given on fourth and fifth days, 15 cubic centimeters at each time.

3. Male, one year (November, 1895). Treatment begun fourth day of illness. Membrane slight, on both tonsils. Slight improvement and increase of membrane; cough and dyspnoea; glands of neck slightly enlarged; heart weak, rapid and irregular. Antitoxin, 10 cubic centimeters on fourth day and 10 cubic centimeters on sixth day.

4. Male, one year, eight months (December, 1895). Moderate prostration, no membrane visible; grows worse; dyspnoea; glands not enlarged; pulse rapid; moderate prostration. Intubation, second day; convulsions on sixth day and death same day. Antitoxin, 10 cubic centimeters on second day and 20 cubic centimeters third day.

5. Female, one year, four months (Dec. 2, 1895). Treatment begun fourth day of illness. General condition bad; membrane on both tonsils; purulent discharge. Throat clear on third day; hoarseness, cough, dyspnoea and stenosis; glands enlarged; pulse weak. Intubation on fifth day; death during intubation. Antitoxin, 8 cubic centimeters on fourth day.

6. Male, twenty-four years (Oct. 16, 1895). Treatment begun third day of illness. Great cyanosis and prostration; membrane on both tonsils and right portion of pharynx; hoarseness, cough and dyspnoea; pulse weak, 100-140, temperature, 100-102; considerable prostration. Antitoxin, third day, morning, 12 cubic centimeters; afternoon, 8 cubic centimeters. Death, fifth day.

7. Male, five years, six months (Oct. 7, 1895). Membrane over tonsils and arches; glands enlarged; pulse irregular and intermittent; paralysis of heart; death. Eruption on whole body, like scarlet fever. Antitoxin, 15 cubic centimeters (day not stated), 5 cubic centimeters on following day.

8. Female, four years (Sept. 21, 1895). Treatment begun second day of illness. Prostration marked; membrane on both tonsils and half arches; glands much enlarged; pulse very weak; urine albuminous; delirium and death. Antitoxin on second day, 15 cubic centimeters. Extravasated blood spots on body after injection.

9. Female, eight years (Sept. 27, 1895). Toxæmia from outset; membrane on tonsils, uvula and posterior pharynx; profuse nasal discharge; marked swelling of glands; pulse rapid and weak. Death on fourth day. Antitoxin, 30 cubic centimeters.

10. Male, nine months (Sept. 7, 1895). Treatment begun fourth day of illness. Temperature, 103-104; pulse, 160-175. Extreme septic appearance; prostration; no membrane; coryza; increasing nasal discharge; dyspnoea; glands very much enlarged on both sides. Antitoxin, 10 cubic centimeters on fourth day.

11. Male, nine months (June 25, 1895). Treatment begun fifth day of illness. Temperature, 101.5-102.1; pulse, 140-170; marked prostration; hoarseness, cough and dyspnoea; glands swollen and tender; heart weak and rapid. Antitoxin, 12 cubic centimeters on fifth day.

12. Male, nine years (Sept. 4, 1895). Treatment begun second day of illness. Temperature, 99-101; pulse, 100-120. Slight prostration; membrane on tonsils, uvula and posterior wall of pharynx; not separated; hoarseness and dyspnoea; glands enlarged; heart normal; urine mal. Antitoxin, 10 cubic centimeters on second day.

3. Male, three years. Treatment begun April 7, 1895, sixth day of illness. Temperature, 99.4-100.5; pulse, 104-135; drowsy; no membrane; coryza on sixth day, less on seventh day; glands enlarged; bronchopneumonia. Antitoxin, 20 cubic centimeters sixth day, 20 cubic centimeters seventh day.



14. Female, two years (May 20, 1895). Treatment begun fourth day of illness. Temperature, 102–104; pulse, 160; moderate prostration; drowsy; membrane covering tonsils and uvula, separating on fifth day; glands enlarged and indurated; urine scanty and albuminous. Antitoxin, 15 cubic centimeters fourth day, 10 cubic centimeters fifth day and 5 cubic centimeters sixth day.

15. Female, three years (treatment begun May 25, 1895, seventh day of illness). Temperature, 101; pulse, 112–116; marked prostration; membrane generally over tonsils and pharynx; glands not swollen; pulse weak, but regular; urine very albuminous; specific gravity, 1032. Antitoxin, 15 cubic centimeters on seventh day.

16. Male, three and one-half years (treatment begun May 25, 1895, fourth day of illness). Temperature, 99–100; pulse, 132–152; slight prostration, increasing on fifth day; membrane over tonsils, palate and uvula, separating on fifth day; hoarseness and slight dyspnoea; glands on right side enlarged; pulse rapid; prostration and dyspnoea increasing till death. Antitoxin, 15 cubic centimeters on fourth day, A.M., 10 cubic centimeters P.M. and 10 cubic centimeters on fifth day, A.M.

17. Male, seven years (treatment begun April 25, 1895, fifth day of illness). Considerable prostration; hoarseness; cough; dyspnoea; stenosis; urine albuminous; intubation; complicated with scarlet fever and measles. Died at 9.15 P.M., fifth day. Antitoxin, 20 cubic centimeters on fifth day.

18. Female, three years (treatment begun May 1, 1895). Slight prostration; membrane on tonsils, disappearing May 18; glands enlarged; complicated with scarlet fever. Died May 18. Antitoxin 20 cubic centimeters May 1, 20 cubic centimeters May 18.

#### *Cambridge Hospital.*

19. Female, one year, six months (admitted Aug. 14, 1895, fifth day of illness). Temperature, 101.6; pulse, 136, on fifth day. Considerable toxæmia; membrane over both tonsils, separating; hoarseness; glands enlarged and hard; heat normal; general paralysis and death September 18. Antitoxin, 12 cubic centimeters on fifth day and 12 cubic centimeters on sixth day. Negative culture on August 31, followed by rash all over body, gradually disappearing.

#### *Boston City Hospital.*

20. Sex not stated, four years (admitted June 1, 1895). Treatment begun third day of illness. General condition weak; membrane on both tonsils, separating on fifth day; glands swollen; heart weak; child vomits everything. Antitoxin, 10 cubic centimeters on third day, 10 cubic centimeters on fourth day.

21. Female, three and one-half years (admitted May 1, 1895). Treatment begun fourth day of illness. Temperature, 99; pulse, 134; slight prostration; membrane on both tonsils and in pharynx; throat nearly clear on seventh day; tonsils slightly enlarged; heart rapid; urine albuminous; bronchitis. Antitoxin, 15 cubic centimeters on fourth day. Removed from another hospital without consent of physician.

22. Female, four years (admitted June 11, 1895). Treatment late. Temperature, 103; pulse, 120; general condition bad; membrane on uvula and tonsils, separating; dyspnoea; glands not swollen; heart weak. Antitoxin, 20 cubic centimeters (1-50,000). Injection delayed on account of objections of family. Death from suffocation four and one-half hours after injection.

23. Female, nine years (admitted July 12, 1895). Treatment begun second day of illness. Temperature, 101.2-103; pulse, 60-150; general condition good; some prostration; membrane on left tonsil and soft palate; glands of neck swollen; pulse regular, rapid; urine normal; thin, glairy discharge from mouth. Antitoxin, 12 cubic centimeters on second day, 12 cubic centimeters on second day, 13 cubic centimeters on third day.

24. Female, two years (admitted May 3, 1895, fifth day of illness). Temperature, 102.3; pulse, 126; membrane thick on both tonsils; hoarseness and dyspnoea; glands slightly swollen; circulation poor; prostration; complicated with sepsis. Antitoxin, 20 cubic centimeters on fifth day.

25. Male, six years (admitted May 9, 1895). Temperature, 98-101; pulse, 100-132; great prostration; membrane thick on tonsils, uvula, pharynx and soft palate, separating third day after admission to hospital; hoarseness and dyspnoea; glands enlarged; pulse weak. Antitoxin, 20 cubic centimeters May 9, A.M., 20 cubic centimeters May 9, P.M., 20 cubic centimeters May 11.

26. Female, one year, six months (admitted April 26, 1895). Temperature, 99.4-104; pulse, 110-160; considerable prostration; membrane on tonsils and uvula; purulent discharge from nose; separating April 29; glands swollen; broncho-pneumonia, complicated with sepsis. Antitoxin, 15 cubic centimeters April 26, 12.5 cubic centimeters April 27.

27. Female, one year, six months (admitted April 29, 1895). Temperature, 98.4-102; pulse, 120-160; slight prostration; membrane on tonsils; no change; glands swollen; urine albuminous; sepsis May 4; extreme prostration May 3. Antitoxin, 20 cubic centimeters April 29.

28. Female, six years (admitted May 15, 1895). Temperature, 98-100.8; pulse, 68-140; extreme prostration; thick membrane over both tonsils, uvula and soft palate; purulent discharge from nose; epistaxis; no improvement; hoarseness, cough and dyspnoea; glands slightly swollen; pulse weak; heart failure May 22; complicated with scarlet fever. Antitoxin, Gibier's, May 15, 25 cubic centimeters; S. B. H., May 16, 25

cubic centimeters; S. B. H., May 17, 25 cubic centimeters; S. B. H., May 18, 25 cubic centimeters.

29. Male, three years (admitted May 15, 1895, second day of illness). No prostration; membrane in small patches on tonsils; separating; throat clear on second day; stenosis; glands not swollen; heart and urine normal; scarlet fever; pneumonia in left chest on fourth day. Antitoxin, 20 cubic centimeters second day, third day and fourth day.

30. Male, three years (admitted May 26, 1895, second day of illness). Prostration; patches on tonsils; hoarseness, cough, dyspnoea and croup; glands slightly enlarged; heart weak; tracheotomy; pneumonia. Antitoxin, 20 cubic centimeters on second day, fourth day and fifth day.

31. Male, five years (admitted May 29, 1895). Extreme prostration; membrane thick on tonsils and uvula; no change; dyspnoea; glands slightly swollen; pulse very weak and irregular; heart failure; sepsis. Antitoxin, 20 cubic centimeters, May 29 and May 30.

32. Female, five years (admitted May 24, 1895). Considerable prostration; membrane one-third over tonsils and uvula; separating May 31; glands not swollen; sepsis June 9; great prostration; great pain; delirium. Antitoxin, 20 cubic centimeters, May 24, 25, 27 and 30.

33. Male, four and one-half years (admitted April 16, 1895, third day of illness). Temperature, 98.4–102; pulse, 112–160; considerable prostration; membrane on tonsils and uvula, diminishing on fifth day; glands enlarged; broncho-pneumonia. Antitoxin, 20 cubic centimeters on third day, 20 cubic centimeters on fourth day and 20 cubic centimeters on fifth day.

34. Male, four years (admitted April 13, 1895, sixth day of illness). Temperature, 100; pulse, 120; condition very septic; membrane on tonsils and uvula; urine albuminous. Antitoxin, 20 cubic centimeters on sixth day.

35. Female, two years (admitted April 22, 1895). Temperature, 98–100.4; pulse, 100–152; condition extremely septic; membrane on tonsils and uvula; epistaxis on April 24; glands enlarged; urine slightly albuminous; extreme prostration April 25. Antitoxin, 20 cubic centimeters, April 22.

#### *Newton Hospital.*

36. Female, twenty-two years (admitted March 24, 1895, fourth day of illness). Temperature, 99.8–103.8; pulse, 100–108; marked prostration; membrane over tonsils, uvula and post-pharyngeal wall, separating on fifth day; throat clear on ninth day; hoarseness and dyspnoea; glands swollen; pulse irregular. Antitoxin, 10 cubic centimeters on fourth day, 23 cubic centimeters fifth day, 15 cubic centimeters sixth day, A.M., 23 cubic centimeters P.M., 23 cubic centimeters seventh day.

An exact statement cannot be made as to the strength of the rum used in each of the foregoing cases, but it may be said in general terms that those treated before Jan. 1, 1896, were treated with a weaker serum, 1 to 50,000, and the remainder with the stronger rum, 1 to 75,000 or 1 to 100,000.

The value of antitoxin as a therapeutic agent cannot be determined by figures alone. The varied circumstances and conflicting conditions which surround and influence any case of diphtheria are great that we are compelled to seek other sources of information than those which are purely statistical in their character.

The clinical experience of the multitude of observers, who, in hospital and in private practice, during the past two years have testified its value, must be weighed and considered in connection with the statistical facts presented.

Dr. Mason makes the following statement relative to the use of antitoxin at the Boston City Hospital in 1895:—

If we compare this death-rate from diphtheria of 11 per cent. since the introduction of antitoxin with that of a death-rate in the hospital of 40 per cent. before the introduction of antitoxin, there can be but one opinion regarding the efficacy of the remedy.

The change in the appearance of diphtheria wards since the introduction of the use of antitoxin has been very marked. In making a visit one cannot help being struck with the bright and cheerful appearance of the children.\*

One of the most noted German authorities (Baginsky) says:—

Naked figures are so little the expression of the endless variations of clinical observation, of all those fortunate and unfortunate accidental circumstances which pertain to the constitution and nutrition of the patient, and of the complications and difficulties which may bring danger in a mild attack, or lead to a successful issue in an apparently severe attack, that to the clinical observer such figures appear of little value, in comparison with the treasure-house of his accumulated experience.

One of the most convincing proofs of the value of antitoxin is mentioned by the same writer, in what he terms an *involuntary* experiment, “where, in consequence of an interruption of the use of antitoxin at a well-known hospital, in consequence of the failure of the supply, for a period of a few weeks the mortality among the diphtheria patients immediately rose again to its former height.”

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\* Boston Medical and Surgical Journal, Feb. 13, 1896, p. 178.

The following extracts are from the returns made to the Board by physicians using the serum : —

“This case was one that, before the days of culture tests, would have been called an undoubted case of true diphtheria, and I did not feel justified in waiting for the result of the culture to be reported to me before making use of the antitoxin.”

“Child got on without any set-back whatever. I have never had a case do so well before using antitoxin.”

“No local treatment. Internally, some tincture of iron, brandy and nourishing diet. Within twelve hours after injection of antitoxin child began to improve both in general and local symptoms.”

“Improvement in twenty-four hours was remarkable.”

“I have no doubt that antitoxin treatment has done much to help save these cases.” (By physician of forty years' experience.)

“These cases, it seems to me, furnish undoubted proof of the efficacy of antitoxin. . . . The beneficial effects were almost immediate. No extension of the membrane occurred. It was being expelled on the second day, and on the fourth day the throat was clear. Improvement in the general condition was also rapid. The result is all I think could be expected or desired.”

“This case was a highly satisfactory one in the marked improvement immediately following antitoxin.”

“The case was a very severe one, and would probably have proved fatal had not the disease been arrested promptly by the use of antitoxin. Four adults concerned more or less in the care of the child were immunized each with 5 cubic centimeters antitoxin. All escaped the disease.” (Physician of thirty years' experience.)

“In this case the disease seemed to have been arrested by the antitoxin.”

“This is my first experience in the use of antitoxin. The result is exceedingly gratifying to me and to the parents. The change in the appearance of the fauces was very apparent six hours afterward. After the second injection the membrane cleared off as I have never seen it before, and the patient's symptoms disappeared with a rapidity to which I am entirely unaccustomed. I ascribe this remarkable change to the use of the serum.”

“I consider that the use of antitoxin in this case was not only beneficial but absolutely the only curative agent.”

“I have been in the habit of seeing such cases die. I think the favorable result may honestly be attributed to the use of antitoxin.”

“Sixteen others, of all ages, living in the same house, were immunized; none of them had diphtheria.”

"Child recovered. This was one of those cases that usually proves fatal in about twenty-four hours under the old treatment."

"Action of antitoxin marvellous."

"My cases have fortunately done well, and it seems to me to be due to the prompt use of the antitoxin." (A physician of thirty years' practice.)

"In this family there occurred seven cases of diphtheria. I am satisfied that without antitoxin I should have lost four of them."

"This patient began to improve after using antitoxin."

"Since last December I have treated thirty-two cases of true diphtheria; the first eight without antitoxin, of which four died; and the remaining twenty-four with antitoxin, with only one death. At least half of the last series of cases were as severe as the first eight."

"A physician of more years in experience than myself, who saw the patient the day of the injection, considered that the case was hopeless without the antitoxin."

"Antitoxin saved this child's life."

"Rapid improvement from time of injection."

The following conclusions and recommendations are selected from the work of Baginsky, already quoted, in consequence of their practical value:—

3. The antitoxin has proved, from the first, an efficient and the best means for the prevention of diphtheria.

4. The technique of injection corresponds with that of ordinary subcutaneous injections, and in like manner presupposes the strict employment of aseptic methods.

5. (a) The serum acts most successfully the sooner it is applied after first appearance of illness. A combination of its use with the ordinary topical local treatment of diphtheria is entirely rational, and is recommended for practical use. By this combined method we have succeeded in diminishing the fatality to one-third of its former rate.

b) The dose depends on the early or late period of its employment, the severity of illness and the age of the patient. It varies from 600 to 4,000 toxin units. An advantage is gained by using the whole dose at the outset. Nevertheless, in stubborn cases an increased dose may be given.

The effect of the remedy is manifest in the limitation and arrest of local processes; also in the rapid dissolution and removal of the disintegrating product and in the general improvement, which generally shows itself as a lessening of febrile reaction.

The remedy appears most efficient in non-septic cases of diphtheria; nevertheless, cases in which mixed infectious and septic diphtheria are concerned are favorably affected by its use. A larger dose is necessary in such cases.

8. The use of the antitoxin is followed by no serious results or illness. The eruptions which often follow its use, although attended with swollen glands or affections of the joints, are wholly without danger. Kidney or heart symptoms do not result from its use.

The following list presents the names of the cities and towns from which detailed reports were received relative to the use of antitoxin, with the number from each town and the number of physicians reporting in each:—

*List of Cities and Towns from which Reports have been received Relative to the Use of Antitoxin in the Treatment of Diphtheria, with the Number of Reports from Each and the Number of Physicians reporting in Each.*

| PLACES.                    | Number Physicians reporting. | Cases in which Cultures made. | No Cultures. | PLACES.                      | Number Physicians reporting. | Cases in which Cultures made. | No Cultures. |
|----------------------------|------------------------------|-------------------------------|--------------|------------------------------|------------------------------|-------------------------------|--------------|
| Boston, . . . . .          | 32                           | 89                            | 28           | Haverhill, . . . . .         | 4                            | -                             | 0            |
| Dorchester, . . . . .      | -                            | 7                             | 2            | Stoneham, . . . . .          | 2                            | -                             | 11           |
| Allston, . . . . .         | -                            | 3                             | -            | Amesbury, . . . . .          | 3                            | -                             | 7            |
| Brighton, . . . . .        | -                            | 2                             | -            | Waltham, . . . . .           | 1                            | 3                             | -            |
| South Boston, . . . . .    | -                            | 10                            | 2            | Arlington, . . . . .         | 3                            | 1                             | 4            |
| Roxbury, . . . . .         | -                            | 7                             | -            | Millbury, . . . . .          | 3                            | 1                             | 3            |
| Mattapan, . . . . .        | -                            | 1                             | -            | Westborough, . . . . .       | 1                            | 3                             | 1            |
| Jamaica Plain, . . . . .   | -                            | 1                             | -            | Lawrence, . . . . .          | 1                            | 1                             | -            |
| Charlestown, . . . . .     | -                            | -                             | 1            | Beverly, . . . . .           | 2                            | 2                             | 5            |
| Cambridge, . . . . .       | 23                           | 37                            | 12           | Milford, . . . . .           | 2                            | 1                             | 2            |
| Cambridgeport, . . . . .   | -                            | -                             | 11           | Belmont, . . . . .           | -                            | 2                             | -            |
| North Cambridge, . . . . . | -                            | -                             | 5            | Milton, . . . . .            | 1                            | 2                             | -            |
| Woburn, . . . . .          | 8                            | 4                             | 55           | Dalton, . . . . .            | 2                            | -                             | 9            |
| Everett, . . . . .         | 8                            | 21                            | 11           | Quincy (West), . . . . .     | 1                            | -                             | 2            |
| Winchester, . . . . .      | 5                            | 5                             | 17           | Sharon, . . . . .            | 1                            | -                             | 5            |
| Lynn, . . . . .            | 14                           | 4                             | 21           | Weymouth, . . . . .          | 1                            | -                             | 2            |
| Lowell, . . . . .          | 7                            | 9                             | -            | East Weymouth, . . . . .     | -                            | -                             | 1            |
| Worcester, . . . . .       | 25                           | 24                            | 8            | Somerville, . . . . .        | 3                            | -                             | 1            |
| Taunton, . . . . .         | 4                            | 9                             | 3            | West Somerville, . . . . .   | -                            | -                             | 1            |
| Brookline, . . . . .       | 4                            | 7                             | 1            | Foxborough, . . . . .        | 2                            | 2                             | 1            |
| Malden, . . . . .          | 4                            | 3                             | 6            | Medford, . . . . .           | -                            | -                             | 2            |
| Newton, . . . . .          | 5                            | -                             | 1            | Westfield, . . . . .         | 1                            | -                             | 2            |
| Newtonville, . . . . .     | -                            | 5                             | -            | Braintree, . . . . .         | 2                            | -                             | 1            |
| West Newton, . . . . .     | -                            | 1                             | -            | South Braintree, . . . . .   | -                            | -                             | 2            |
| Upper Falls, . . . . .     | -                            | 3                             | -            | Melrose Highlands, . . . . . | -                            | -                             | 2            |
| Auburndale, . . . . .      | -                            | 2                             | -            | Bedford, . . . . .           | 1                            | 2                             | -            |

*Cities and Towns from which Reports have been received Relative to the Use of Antitoxin, etc. — Concluded.*

| PLACES.              | Number Phys-<br>icians report-<br>ing. | Cases in which<br>Cultures made | No Cultures. | PLACES.                     | Number Phys-<br>icians report-<br>ing. | Cases in which<br>Cultures made | No Cultures. |
|----------------------|----------------------------------------|---------------------------------|--------------|-----------------------------|----------------------------------------|---------------------------------|--------------|
| . . . . .            | 2                                      | -                               | 2            | Canton, . . . . .           | 1                                      | -                               | 1            |
| . . . . .            | -                                      | 1                               | -            | Ware, . . . . .             | 1                                      | -                               | 1            |
| . . . . .            | 1                                      | 1                               | 1            | Rockland, . . . . .         | 1                                      | -                               | 1            |
| . . . . .            | 1                                      | 1                               | -            | Swampscott, . . . . .       | 1                                      | -                               | 1            |
| ge, . . . . .        | -                                      | 1                               | -            | Westhampton, . . . . .      | -                                      | -                               | 1            |
| . . . . .            | 1                                      | 1                               | -            | Hudson, . . . . .           | 1                                      | -                               | 1            |
| . . . . .            | 3                                      | -                               | 1            | Norwood, . . . . .          | 1                                      | -                               | 1            |
| . . . . .            | 1                                      | -                               | 1            | Northborough, . . . . .     | 1                                      | -                               | 1            |
| igh, . . . . .       | -                                      | -                               | 1            | Monson, . . . . .           | 1                                      | -                               | 1            |
| leborough, . . . . . | 2                                      | -                               | 1            | North Brookfield, . . . . . | 1                                      | -                               | 1            |
| l, . . . . .         | 1                                      | -                               | 1            | Ludlow, . . . . .           | 1                                      | -                               | 1            |

soon as the discovery of the new remedy, *diphtheria anti-* was made known to the world, and the methods of its prepara- were also made public, several establishments both in Europe America undertook its manufacture, and different brands of in were offered for sale. In order, therefore, that the of the different preparations of so important a remedy might rmined for the benefit of local boards of health, hospitals and ans in active practice throughout the State, the State Board lth, acting under the provisions of the food and drug act of directed an examination of the preparations in the market to le, and published the result in a circular, of which the follow- copy :—

STATE HOUSE, BOSTON, April 6, 1896.

r authority of the statutes relating to food and drug inspection, the oard of Health has examined such samples of antitoxin as are for sale in Massachusetts, with the following results :—

n No. 2, Behring. Bottle containing 10 cubic centimeters of of an advertised strength of 1,000 units. The test showed that the as up to the standard.

a of Parke, Davis & Co. Bottle guaranteed to contain 10 cubic ters, of a total strength of 1,000 units. The test showed that the as up to the standard.



Serum No. 2 of Mulford & Co. The label states that the bottle contains 10 cubic centimeters, of a total strength of 1,000 units. The test confirmed the statement, and showed the serum to be up to the guaranteed strength.

Serum of the Pasteur Institute of Paris, France (Roux). The circular states that the serum is at least 1 to 50,000 in strength. As this is considered equivalent to Behring's serum No. 1, the test was carried out with this strength in view. It was, however, found to be weaker than this. A second test showed that the 10 cubic centimeters of serum contained a total of 500 antitoxic units, instead of 600 units.

Gibier's Diphtheria Antitoxin, New York. The label states that the bottle contains 25 cubic centimeters, of a total strength of 2,500 units. The test showed that the serum was far below this in strength. In a second test it was determined that the bottle contained from 625 to 750 units, instead of 2,500, as advertised. The strength of this serum is thus a trifle below one-half of that of Behring's serum No. 1.\*

THE STATE BOARD OF HEALTH.

Copies of the foregoing circular were distributed generally among physicians and boards of health throughout the State.

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\* Ten cubic centimeters of Behring's serum No. 1 contain 600 units.

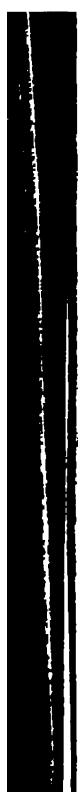
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# STATISTICAL SUMMARIES.

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## STATISTICAL SUMMARIES OF DISEASE AND MORTALITY.

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the last report of the Board, the statistical material collected by the Board was published together under the head of "Statistical Summaries of Disease and Mortality." These summaries comprise statistics obtained from the authorities of cities and towns, and partly voluntary and partly the result of legal requirements. They are as follows:—

*The Weekly Mortality Returns.*—These consist of the reports of deaths, which are made up weekly and are sent to the office of the State Board by the registration officials of cities and towns. They are partly voluntary, and serve principally to show the seasonal prevalence of the chief infectious diseases, and the mortality of children under five years old in weekly periods. This series of statistics has been continued by the Board for at least twenty years, and has been published as a summary for thirteen years.

*The Reports of Certain Infectious Diseases,—Diphtheria, Croup, Scarlet Fever, Typhoid Fever and Measles.*—These are obtained from the annual reports of local boards of health for the year ending, which are forwarded to the State Board from cities and towns. By comparing the numbers of reported cases with the reported deaths, the mean fatality of each disease in the places from which the reports are made is obtained with a reasonable degree of accuracy.

*Reports of Cities and Towns, made under the Provisions of Chapter 302 of the Acts of 1893.*—By this act each local board of health is required to report to the State Board every case of "disease dangerous to the public health" which is reported to the local board. A digest of these reports is presented in the following summary (No. III.).

*Reports made under the provisions of Chapter 218 of the Acts of 1894.*—The full reports of deaths occurring in each city and town having over 5,000 inhabitants comprise another series of summaries, which are summarized in No. IV. These reports are made in accordance with the requirements of the following statute:—

### [ACTS OF 1894, CHAPTER 218, SECTION 3.]

In each city and town having a population of more than five thousand inhabitants, as determined by the last census, at least one member of said board shall be a physician, and the board shall send an annual report of deaths in such town to the State Board of Health. The form of such reports shall be prescribed and furnished by the State Board of Health.

## I.

SUMMARY OF THE WEEKLY MORTALITY RETURNS FROM  
CITIES AND TOWNS.

The following summary comprises the returns of deaths which are reported to the State Board of Health at the close of each week by such registration officials of cities and towns as comply with the request of the State Board of Health for this information. The data thus collected are entirely obtained from voluntary sources, and the results are compiled at the office of the board each week for publication in a bulletin which is distributed to the registering officers of the cities and towns. The facility of distributing this bulletin has been recently increased in consequence of a change in the postal laws, which admits the bulletin to the mails at a diminished rate of postage. It is also a useful medium for the publication of such information as it may become desirable to issue at more frequent intervals than is possible in the annual reports of the Board. The value of the weekly mortality returns consists very largely in the fact that they constitute a continuous history of the prevalence of the principal infectious diseases throughout the State, so far as can be learned from the mortality which they cause.

In connection with the results of the information obtained as a consequence of the enactment of chapter 302 of the Acts of 1893, these weekly mortality reports furnish to the Board an important index of the health of the people, as influenced by the prevalence of epidemic diseases at different seasons of the year.

The estimated mean population contributing to these returns during the year 1895 was about 1,495,000, or about three-fifths of the total population.

the data embraced in this summary are the following : —

Average height of barometer for each week.

Mean maximum temperature.

Mean minimum temperature.

Rainfall expressed in inches.

Humidity.

Total deaths reported for each week.

Deaths of children under five years.

Deaths from infectious diseases.

Deaths from consumption.

Deaths from acute lung diseases.

Deaths from typhoid fever.

Deaths from diarrhoeal diseases.

Deaths from scarlet fever.

Deaths from measles.

Deaths from diphtheria and croup.

Deaths from puerperal fever.

Deaths from whooping-cough.

Deaths from malarial fever.

Deaths from small-pox.

Deaths from erysipelas.

The following table presents a summary of the statistics compiled from the weekly mortality returns : —

## Summary.

| DATE.    | Barometer. | Max im um Ther-<br>mometer. Mean<br>for Each Week. | Min im um Ther-<br>mometer. Mean<br>for Each Week. | Rain. Inches per<br>month. | Humidity. | Total Deaths. | Deaths under Five<br>Years of Age. | Consumption. | Acute Lung<br>Diseases. | Typhoid Fever. | Diphtheria<br>and Croup. | Scarlet Fever. | Measles. | Diarrhoeal Diseases. | Whooping-cough. | Malarial Fever. | Small-pox. | Pneumonal Fever. | Krysinpolis. |
|----------|------------|----------------------------------------------------|----------------------------------------------------|----------------------------|-----------|---------------|------------------------------------|--------------|-------------------------|----------------|--------------------------|----------------|----------|----------------------|-----------------|-----------------|------------|------------------|--------------|
|          |            |                                                    |                                                    |                            |           |               |                                    |              |                         |                |                          |                |          |                      |                 |                 |            |                  |              |
| Jan. 5,  | 30.15      | 29                                                 | 15                                                 | -                          | 58        | 536           | 198                                | 47           | 78                      | 9              | 35                       | 11             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 12,      | 30.17      | 29                                                 | 29                                                 | -                          | 88        | 546           | 183                                | 40           | 96                      | 9              | 35                       | 10             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 19,      | 29.96      | 27                                                 | 22                                                 | -                          | 72        | 476           | 170                                | 46           | 84                      | 9              | 35                       | 9              | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 26,      | 29.82      | 38                                                 | 22                                                 | 3.46                       | 65        | 538           | 183                                | 72           | 95                      | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| Feb. 2,  | 30.09      | 30                                                 | 18                                                 | -                          | 70        | 603           | 169                                | 70           | 110                     | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 9,       | 29.70      | 26                                                 | 5                                                  | -                          | 66        | 559           | 218                                | 72           | 100                     | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 16,      | 29.85      | 36                                                 | 19                                                 | -                          | 66        | 593           | 198                                | 80           | 166                     | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 23,      | 29.82      | 38                                                 | 23                                                 | 1.05                       | 61        | 743           | 226                                | 88           | 209                     | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| March 2, | 29.85      | 23                                                 | 40                                                 | -                          | 66        | 800           | 193                                | 84           | 217                     | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 9,       | 29.98      | 38                                                 | 26                                                 | -                          | 77        | 678           | 196                                | 84           | 156                     | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 16,      | 30.03      | 38                                                 | 26                                                 | -                          | 66        | 632           | 148                                | 66           | 196                     | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 23,      | 30.00      | 39                                                 | 27                                                 | -                          | 62        | 596           | 178                                | 74           | 116                     | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 30,      | 29.89      | 46                                                 | 31                                                 | 2.66                       | 62        | 620           | 147                                | 68           | 128                     | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| April 6, | 29.94      | 45                                                 | 31                                                 | -                          | 53        | 546           | 160                                | 76           | 112                     | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 13,      | 30.11      | 61                                                 | 39                                                 | -                          | 66        | 623           | 208                                | 76           | 122                     | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 20,      | 29.97      | 51                                                 | 39                                                 | -                          | 70        | 533           | 152                                | 63           | 100                     | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 27,      | 30.07      | 63                                                 | 44                                                 | 4.54                       | 61        | 583           | 195                                | 63           | 100                     | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| May 4,   | 30.27      | 63                                                 | 43                                                 | -                          | 76        | 546           | 186                                | 64           | 85                      | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 11,      | 30.04      | 81                                                 | 58                                                 | -                          | 66        | 552           | 179                                | 56           | 89                      | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 18,      | 29.96      | 59                                                 | 43                                                 | -                          | 64        | 506           | 182                                | 68           | 78                      | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 25,      | 30.14      | 66                                                 | 49                                                 | 2.52                       | 57        | 560           | 117                                | 53           | 78                      | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| June 1,  | 29.89      | 75                                                 | 57                                                 | -                          | 69        | 490           | 135                                | 69           | 68                      | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 8,       | 30.09      | 70                                                 | 58                                                 | -                          | 69        | 497           | 147                                | 87           | 64                      | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 15,      | 30.05      | 80                                                 | 61                                                 | -                          | 68        | 418           | 118                                | 62           | 36                      | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 22,      | 30.15      | 74                                                 | 61                                                 | -                          | 74        | 422           | 113                                | 59           | 28                      | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 29,      | 30.06      | 69                                                 | 61                                                 | 2.81                       | 88        | 368           | 110                                | 41           | 30                      | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| July 6,  | 30.01      | 74                                                 | 60                                                 | -                          | 75        | 401           | 182                                | 43           | 39                      | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 13,      | 29.96      | 77                                                 | 62                                                 | -                          | 74        | 487           | 166                                | 56           | 16                      | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 20,      | 30.01      | 74                                                 | 60                                                 | -                          | 78        | 584           | 290                                | 58           | 35                      | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 27,      | 29.90      | 81                                                 | 65                                                 | 3.86                       | 67        | 638           | 327                                | 51           | 23                      | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| Aug. 3,  | 29.88      | 76                                                 | 59                                                 | -                          | 68        | 650           | 358                                | 41           | 31                      | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 10,      | 29.92      | 84                                                 | 66                                                 | -                          | 64        | 723           | 392                                | 41           | 18                      | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 17,      | 29.94      | 77                                                 | 74                                                 | -                          | 78        | 612           | 399                                | 41           | 20                      | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 24,      | 29.94      | 76                                                 | 74                                                 | -                          | 78        | 612           | 399                                | 41           | 20                      | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |
| 31,      | 29.96      | 76                                                 | 69                                                 | 3.16                       | 72        | 638           | 392                                | 41           | 20                      | 2              | 32                       | 12             | 1        | 3                    | 4               | 1               | 1          | 1                | 1            |





## TOTAL DEATHS.

The whole number of deaths reported for the year 1895 from the cities and towns contributing to these reports was 28,978, and the average number per week was 557. The greatest number of deaths reported in a single week was 800, in the week ending March 2, and the least number was 368, in the week ending June 29. The weekly average number of deaths reported for each month was:—

|                     |     |                      |     |
|---------------------|-----|----------------------|-----|
| January, . . . . .  | 529 | July, . . . . .      | 515 |
| February, . . . . . | 658 | August, . . . . .    | 617 |
| March, . . . . .    | 665 | September, . . . . . | 567 |
| April, . . . . .    | 571 | October, . . . . .   | 542 |
| May, . . . . .      | 538 | November, . . . . .  | 518 |
| June, . . . . .     | 438 | December, . . . . .  | 535 |

The months in which the greatest mortality per week was reported were February, March and August, and those in which there was the least reported mortality were June, July and November.

The percentages of mortality in each of the four quarters of the year were as follows:—

|                           | DEATHS AT ALL AGES. |              | DEATHS UNDER FIVE YEARS. |              |
|---------------------------|---------------------|--------------|--------------------------|--------------|
|                           | Numbers.            | Percentages. | Numbers.                 | Percentages. |
| First quarter, . . . . .  | 8,080               | 27.88        | 2,376                    | 23.49        |
| Second quarter, . . . . . | 6,629               | 22.88        | 1,937                    | 19.15        |
| Third quarter, . . . . .  | 7,410               | 25.57        | 3,668                    | 36.27        |
| Fourth quarter, . . . . . | 6,859               | 23.67        | 2,133                    | 21.09        |
|                           | 28,978              | 100.00       | 10,114                   | 100.00       |

The death rate of reporting cities and towns was 19.4 per 1,000, the reporting population being 1,495,000.

## DEATHS UNDER FIVE YEARS.

The reported number of deaths of children under five years of age was 10,114, and the average weekly number was 194. The greatest number reported in one week was 392, in the week ending August

10, and the least number was 110, in the week ending June 29. The ratio of the deaths of this class to the total mortality was 34.9 per cent., which was slightly less than that of the preceding year (36.1 per cent.). The average weekly number of deaths of children under five years of age by months was as follows : —

|                     |     |                      |     |
|---------------------|-----|----------------------|-----|
| January, . . . . .  | 176 | July, . . . . .      | 229 |
| February, . . . . . | 203 | August, . . . . .    | 332 |
| March, . . . . .    | 172 | September, . . . . . | 273 |
| April, . . . . .    | 175 | October, . . . . .   | 198 |
| May, . . . . .      | 153 | November, . . . . .  | 148 |
| June, . . . . .     | 125 | December, . . . . .  | 150 |

The months having the greatest number of deaths of children under five years of age were July, August and September, and those having the least number were June, November and December.

The relation of the death rate of children under five years of age to the death rate at all ages is fully illustrated in the diagram upon page 721 of the twenty-third annual report (1891), where the mean death rate per week for a series of nine years is given. The irregularities in the death rate at all ages in different seasons of the year is shown to be very largely produced by the marked changes in the death rate of children.

#### CONSUMPTION.

The number of reported deaths from consumption was 3,119, and the weekly average was 60. The greatest number of deaths reported from this cause in a single week was 88, in the week ending February 23, and the least number was 41, in the weeks ending June 29, August 3 and August 17.

The average weekly number of reported deaths from this cause in each month was as follows : —

|                     |    |                      |    |
|---------------------|----|----------------------|----|
| January, . . . . .  | 56 | July, . . . . .      | 51 |
| February, . . . . . | 77 | August, . . . . .    | 47 |
| March, . . . . .    | 75 | September, . . . . . | 53 |
| April, . . . . .    | 64 | October, . . . . .   | 59 |
| May, . . . . .      | 60 | November, . . . . .  | 59 |
| June, . . . . .     | 62 | December, . . . . .  | 56 |

The months having the greatest number of deaths from this cause were February and March, and those having the least were July

and September. The following table presents the variations from the weekly average number of deaths from this cause for the past five years :—

|             | 1891. | 1892. | 1893. | 1894. | 1895. |              | 1891. | 1892. | 1893. | 1894. | 1895. |
|-------------|-------|-------|-------|-------|-------|--------------|-------|-------|-------|-------|-------|
| January, .  | +4    | +13   | +8    | +10   | -4    | July, .      | -4    | -3    | -7    | 0     | -9    |
| February, . | -4    | -8    | -3    | +7    | +17   | August, .    | -3    | -4    | -1    | -4    | -13   |
| March, .    | -5    | -1    | +9    | +9    | +15   | September, . | -3    | -11   | -1    | -3    | -7    |
| April, .    | +4    | +7    | +13   | -1    | +4    | October, .   | +3    | -5    | -10   | -6    | -1    |
| May, .      | +6    | 0     | +1    | -7    | 0     | November, .  | -4    | -4    | +2    | -7    | -1    |
| June, .     | -2    | -5    | -9    | -1    | +2    | December, .  | +5    | -1    | -6    | +2    | -4    |

The ratio of reported deaths from consumption to the mortality reported from all causes was 107.7 per 1,000, while that of previous years was as follows :—

|                 |       |                 |       |
|-----------------|-------|-----------------|-------|
| 1888, . . . . . | 134.2 | 1892, . . . . . | 111.3 |
| 1889, . . . . . | 125.0 | 1893, . . . . . | 106.5 |
| 1890, . . . . . | 130.0 | 1894, . . . . . | 111.8 |
| 1891, . . . . . | 116.5 | 1895, . . . . . | 107.7 |

The ratio to the reported living population in 1895 was 2.09 per 1,000.

#### ACUTE LUNG DISEASES.

The number of reported deaths from acute lung diseases (bronchitis, pneumonia, pleurisy and asthma) during the year was 3,937, and the weekly average was 76. The greatest number of deaths reported from this group of causes in a single week was 217, in the week ending March 2; and the least number was 16, in the week ending July 13. The average weekly number of reported deaths from these causes for each month was as follows :—

|                     |     |                      |    |
|---------------------|-----|----------------------|----|
| January, . . . . .  | 89  | July, . . . . .      | 27 |
| February, . . . . . | 146 | August, . . . . .    | 25 |
| March, . . . . .    | 162 | September, . . . . . | 28 |
| April, . . . . .    | 115 | October, . . . . .   | 48 |
| May, . . . . .      | 80  | November, . . . . .  | 68 |
| June, . . . . .     | 41  | December, . . . . .  | 80 |

The months having the greatest number of reported deaths from these causes were February and March, and those having the least number were July and September. The ratio of reported deaths

acute lung diseases to the reported mortality from all causes 135.9 per 1,000. The estimated death rate per 1,000 of the living population from these causes was 2.63, as compared with for the previous year.

#### TYPHOID FEVER.

The total number of reported deaths from this cause was 405, and the weekly average was 8. The greatest number reported in any week from this cause was 23, in the week ending September 1, and the least number was 2, in the weeks ending January 19, February 2, 16, 23 and June 29. The average weekly number of deaths reported from this cause for each month was as follows:—

|                     |   |                      |    |
|---------------------|---|----------------------|----|
| January, . . . . .  | 4 | July, . . . . .      | 5  |
| February, . . . . . | 2 | August, . . . . .    | 12 |
| March, . . . . .    | 5 | September, . . . . . | 16 |
| April, . . . . .    | 6 | October, . . . . .   | 12 |
| May, . . . . .      | 5 | November, . . . . .  | 10 |
| June, . . . . .     | 5 | December, . . . . .  | 11 |

The months having the greatest number of reported deaths from this cause were August, September and November, and those having the least were January, February and May. The ratio of reported deaths from typhoid fever to the reported mortality from all causes was 14.0 per 1,000, and the ratio to the reporting population was 27 per 1,000, as compared with .28 in the previous year.

#### DIPHTHERIA AND CROUP.

The total number of reported deaths from diphtheria and croup in 1905 was 1,289, and the average number in each week was 25. The greatest number reported in a single week from these combined causes was 50, in the week ending November 9; and the least number was 6, in the week ending July 6. The average weekly number of reported deaths from these causes for each month was as follows:—

|                     |    |                      |    |
|---------------------|----|----------------------|----|
| January, . . . . .  | 32 | July, . . . . .      | 12 |
| February, . . . . . | 29 | August, . . . . .    | 16 |
| March, . . . . .    | 18 | September, . . . . . | 25 |
| April, . . . . .    | 21 | October, . . . . .   | 28 |
| May, . . . . .      | 17 | November, . . . . .  | 41 |
| June, . . . . .     | 18 | December, . . . . .  | 42 |

The months having the greatest number of reported deaths per 1,000 from these causes were January, November and December,

and those having the least number were May, July and August. The ratio of deaths from diphtheria and croup to the reported mortality from all causes was 44.48 per 1,000, and the death rate of the reporting population was 86 per 1,000, that of the previous year being 95.

#### SCARLET FEVER.

The reported deaths from scarlet fever in 1895 were 312, and the average weekly number was 6. The greatest number of reported deaths from this cause in a single week was 13, in the weeks ending February 2 and April 13, and the least number reported in a single week was 1, in the weeks ending October 5 and November 9. The average weekly number reported in each month was as follows:—

|                     |    |                      |   |
|---------------------|----|----------------------|---|
| January, . . . . .  | 9  | July, . . . . .      | 6 |
| February, . . . . . | 10 | August, . . . . .    | 4 |
| March, . . . . .    | 8  | September, . . . . . | 5 |
| April, . . . . .    | 8  | October, . . . . .   | 3 |
| May, . . . . .      | 8  | November, . . . . .  | 2 |
| June, . . . . .     | 6  | December, . . . . .  | 3 |

The months having the greatest number of deaths from this cause were February and March, and those having the least number were October and November. The ratio of deaths from this cause to the reported deaths from all causes was 10.80 per 1,000, and the death rate of the reporting population from this cause was .21 per 1,000, that of the previous year being .32.

#### MEASLES.

The total number of reported deaths from measles in 1895 was 71. The greatest number in a single week was 8. There were twenty-two weeks in which no deaths from measles were reported. The average weekly number reported in each month was as follows:—

|                     |   |                      |   |
|---------------------|---|----------------------|---|
| January, . . . . .  | 2 | July, . . . . .      | 2 |
| February, . . . . . | 1 | August, . . . . .    | 0 |
| March, . . . . .    | 1 | September, . . . . . | 0 |
| April, . . . . .    | 2 | October, . . . . .   | 0 |
| May, . . . . .      | 2 | November, . . . . .  | 0 |
| June, . . . . .     | 4 | December, . . . . .  | 1 |

The ratio of deaths to the reporting mortality from all causes was 2.45 per 1,000, and the death rate from this cause was .047 per 1,000 of the reported population, as compared with .03 in 1894.

## DIARRHŒAL DISEASES.

the diseases in this group are diarrhœa, dysentery, cholera infantum and cholera infantum. From these causes combined the number of deaths reported in 1895 was 2,153, and the weekly average number was 41. The greatest number reported in a single week was 193, in the week ending August 8, and the least number 2, in the week ending January 19. The average weekly number of reported deaths from these causes in each month was as follows:—

|                     |    |                      |     |
|---------------------|----|----------------------|-----|
| January, . . . . .  | 4  | July, . . . . .      | 109 |
| February, . . . . . | 7  | August, . . . . .    | 158 |
| March, . . . . .    | 8  | September, . . . . . | 113 |
| April, . . . . .    | 5  | October, . . . . .   | 47  |
| May, . . . . .      | 8  | November, . . . . .  | 12  |
| June, . . . . .     | 13 | December, . . . . .  | 8   |

The months having the greatest number of reported deaths from these causes in 1895 were July, August and September, and those having the least were January, February and April. The deaths from these causes in the third quarter of the year constituted 77.7 per cent. of the number of deaths from the same causes for the year. The ratio of reported deaths to the reported mortality from all causes was 74.29 per 1,000, and the death rate of the reporting population from these causes was 1.44, as compared with 1894.

#### WHOOPING-COUGH, MALARIAL FEVER, ERYSIPELAS AND PUERPERAL FEVERS.

The essential statistics relating to these four diseases are embraced in the following table:—

|                            | Total Deaths Reported. | Weekly Averages. | Ratio per 1,000 of Reported Deaths from All Causes. | Ratio per 1,000 of Reporting Population. |
|----------------------------|------------------------|------------------|-----------------------------------------------------|------------------------------------------|
| Whooping-cough, . . . . .  | 128                    | 2.5              | 4.42                                                | .086                                     |
| Erysipelas, . . . . .      | 66                     | 1.3              | 2.30                                                | .044                                     |
| Malarial fever, . . . . .  | 35                     | .7               | .12                                                 | .023                                     |
| Puerperal fever, . . . . . | 11                     | .2               | .38                                                 | .007                                     |

## II.

FATALITY (*RATIO OF DEATHS TO CASES*) FROM CERTAIN INFECTIOUS DISEASES IN 1895.

The statistics presented in the following table are compiled from the published reports of local boards of health for the year 1895 which have been forwarded to the office of the State Board of Health. They are the figures representing the numbers of cases reported to local boards of health under the provisions of section 79 of chapter 80, Public Statutes.

The numbers of deaths are also obtained from the same reports, and the comparison of these two series of figures presents a fairly accurate method of arriving at the fatality from these diseases in the places from which they are reported. The figures representing the numbers of cases are probably less than the actual numbers, since some cases must necessarily escape registration through neglect to report or in consequence of faulty diagnosis.

*Cases of Infectious Diseases and Deaths reported to Local Boards of Health, 1895.*

| CITY OR TOWN.           | DIPHTHERIA<br>AND CROUP. |         | SCARLET<br>FEVER. |         | TYPHOID<br>FEVER. |         | MEASLES. |         |
|-------------------------|--------------------------|---------|-------------------|---------|-------------------|---------|----------|---------|
|                         | Cases.                   | Deaths. | Cases.            | Deaths. | Cases.            | Deaths. | Cases.   | Deaths. |
| Amesbury, . . . . .     | 24                       | 9       | 65                | 2       | 9                 | 1       | 225      | 4       |
| Andover, . . . . .      | 11                       | -       | 16                | -       | 3                 | -       | -        | -       |
| Attleborough, . . . . . | 6                        | 2       | 12                | -       | 7                 | 3       | 3        | -       |
| Ayer, . . . . .         | 3                        | -       | 65                | -       | 12                | -       | -        | -       |
| Belmont, . . . . .      | 10                       | 1       | 8                 | -       | 1                 | -       | -        | -       |
| Blackstone, . . . . .   | 15                       | 8       | 4                 | -       | 6                 | 1       | 3        | -       |
| Boston, . . . . .       | 4,059                    | 654     | 1,612             | 114     | 1,026             | 163     | 2,733    | 19      |
| Brockton, . . . . .     | 37                       | 13      | 210               | 4       | 25                | 8       | 5        | -       |
| Brookline, . . . . .    | 97                       | 15      | 24                | 1       | 9                 | 3       | 21       | -       |
| Cambridge, . . . . .    | 573                      | 106     | 293               | 17      | 107               | 12      | 249      | 3       |
| Canton, . . . . .       | 3                        | -       | 13                | 1       | 3                 | -       | -        | -       |
| Chelsea, . . . . .      | 173                      | 31      | 151               | 10      | 7                 | 3       | 28       | -       |
| Chicopee, . . . . .     | 12                       | 5       | 65                | 5       | 8                 | 4       | -        | 1       |
| Clinton, . . . . .      | 4                        | 3       | 19                | -       | 9                 | 6       | 185      | 4       |

*Cases of Infectious Diseases, etc.—Continued.*

| CITY OR TOWN.   | DIPHTHERIA<br>AND CROUP. |         | SCARLET<br>FEVER. |         | TYPHOID<br>FEVER. |         | MEASLES. |         |
|-----------------|--------------------------|---------|-------------------|---------|-------------------|---------|----------|---------|
|                 | Cases.                   | Deaths. | Cases.            | Deaths. | Cases.            | Deaths. | Cases.   | Deaths. |
| City, . . . . . | 8                        | -       | 12                | 1       | 1                 | -       | 4        | -       |
| City, . . . . . | -                        | -       | 2                 | -       | -                 | -       | -        | -       |
| City, . . . . . | 2                        | 2       | 37                | 1       | 2                 | 1       | 45       | -       |
| City, . . . . . | 56                       | 7       | 31                | -       | 1                 | -       | 10       | -       |
| City, . . . . . | -                        | -       | 24                | 1       | -                 | -       | -        | -       |
| City, . . . . . | -                        | -       | 45                | -       | 2                 | 1       | 53       | -       |
| City, . . . . . | 55                       | 13      | 60                | 8       | 31                | 5       | 45       | -       |
| City, . . . . . | 88                       | 66      | 272               | 20      | 122               | 30      | -        | -       |
| City, . . . . . | 27                       | 8       | 34                | 1       | 29                | 8       | -        | -       |
| City, . . . . . | 5                        | 2       | 6                 | -       | 6                 | 2       | 34       | 1       |
| City, . . . . . | 39                       | 5       | 2                 | -       | 4                 | 1       | 72       | -       |
| City, . . . . . | -                        | -       | 16                | 2       | 16                | 3       | -        | -       |
| City, . . . . . | 171                      | 25      | 214               | 6       | 23                | 4       | -        | -       |
| City, . . . . . | 4                        | -       | 6                 | 1       | 12                | 3       | 2        | -       |
| City, . . . . . | 16                       | 9       | -                 | -       | -                 | -       | -        | -       |
| City, . . . . . | 24                       | 6       | 98                | 6       | 36                | 8       | 232      | 5       |
| City, . . . . . | 24                       | 1       | -                 | -       | -                 | -       | -        | -       |
| City, . . . . . | 54                       | 20      | 28                | -       | 39                | 12      | 47       | 8       |
| City, . . . . . | 26                       | 5       | 5                 | -       | 3                 | -       | -        | -       |
| City, . . . . . | 6                        | 2       | -                 | -       | -                 | -       | 5        | -       |
| City, . . . . . | 23                       | 7       | 35                | 2       | 16                | 1       | 99       | -       |
| City, . . . . . | 9                        | 3       | 11                | -       | 10                | 1       | 69       | -       |
| City, . . . . . | 13                       | 2       | 5                 | -       | -                 | -       | -        | -       |
| City, . . . . . | 4                        | -       | 13                | -       | 11                | -       | -        | -       |
| City, . . . . . | 1                        | -       | 7                 | -       | 3                 | 2       | 3        | -       |
| City, . . . . . | 5                        | 2       | 6                 | -       | 1                 | 1       | -        | -       |
| City, . . . . . | 120                      | 53      | 160               | 4       | 172               | 33      | 53       | 1       |
| City, . . . . . | 244                      | 42      | 415               | 26      | 104               | 13      | -        | -       |
| City, . . . . . | 10                       | 2       | 10                | 1       | 3                 | -       | 229      | 1       |
| City, . . . . . | 2                        | -       | 8                 | -       | -                 | -       | -        | -       |
| City, . . . . . | 74                       | 9       | 81                | 1       | 29                | 3       | 14       | -       |
| City, . . . . . | 41                       | 6       | 33                | -       | 18                | 4       | 11       | -       |
| City, . . . . . | 8                        | 2       | 36                | 1       | 4                 | 2       | -        | -       |
| City, . . . . . | 6                        | 2       | 15                | -       | 2                 | -       | 2        | -       |
| City, . . . . . | 1                        | -       | -                 | -       | -                 | -       | 1        | -       |
| City, . . . . . | 3                        | 2       | -                 | -       | -                 | -       | -        | -       |



*Cases of Infectious Diseases, etc.—Concluded.*

| CITY OR TOWN.                  | DIPHTHERIA<br>AND CROUP. |         | SCARLET<br>FEVER. |         | TYPHOID<br>FEVER. |         | MEASLES. |         |
|--------------------------------|--------------------------|---------|-------------------|---------|-------------------|---------|----------|---------|
|                                | Cases.                   | Deaths. | Cases.            | Deaths. | Cases.            | Deaths. | Cases.   | Deaths. |
| New Bedford, . . . . .         | 121                      | 30      | 101               | 5       | 79                | 9       | 19       | 1       |
| Newburyport, . . . . .         | 8                        | 1       | 81                | 2       | 19                | 8       | -        | -       |
| Newton, . . . . .              | 158                      | 21      | 92                | 1       | 31                | 3       | 321      | 1       |
| North Adams, . . . . .         | 33                       | 18      | 12                | 1       | 86                | -       | 16       | -       |
| Northampton, . . . . .         | 6                        | 3       | 27                | 1       | 36                | 4       | 9        | -       |
| North Andover, . . . . .       | 2                        | 2       | 21                | -       | -                 | -       | 8        | -       |
| North Attleborough, . . . . .  | 6                        | 1       | 16                | -       | 5                 | 1       | -        | -       |
| North Brookfield, . . . . .    | 24                       | 6       | 1                 | -       | -                 | -       | -        | -       |
| Norwood, . . . . .             | 4                        | -       | 14                | -       | -                 | 5       | -        | -       |
| Palmer, . . . . .              | 18                       | 10      | 79                | 24      | 3                 | 2       | 1        | -       |
| Pittsfield, . . . . .          | 11                       | 8       | 22                | 1       | 14                | 3       | 6        | -       |
| Plymouth, . . . . .            | 10                       | -       | 57                | 2       | 17                | -       | -        | -       |
| Quincy, . . . . .              | 105                      | 17      | 58                | 4       | 19                | 5       | 33       | -       |
| Reading, . . . . .             | 6                        | 1       | 3                 | -       | 34                | 3       | 1        | -       |
| Revere, . . . . .              | 28                       | 4       | 3                 | -       | 4                 | 1       | -        | -       |
| Salem, . . . . .               | 44                       | 4       | 303               | 9       | 38                | 3       | -        | -       |
| Saugus, . . . . .              | 16                       | 2       | 42                | 5       | 5                 | 1       | 2        | -       |
| Somerville, . . . . .          | 246                      | 43      | 217               | 17      | 61                | 10      | -        | -       |
| Springfield, . . . . .         | 30                       | 23      | 121               | 8       | 39                | 9       | 73       | 2       |
| Swampscott, . . . . .          | 14                       | 2       | 4                 | -       | 1                 | -       | 3        | -       |
| Taunton, . . . . .             | 155                      | 26      | 26                | -       | 5                 | 2       | -        | -       |
| Tewksbury, . . . . .           | -                        | -       | 39                | 1       | 3                 | -       | -        | -       |
| Wakefield, . . . . .           | 7                        | 4       | 14                | -       | 8                 | 1       | 12       | -       |
| Waltham, . . . . .             | 115                      | 3       | 32                | 3       | 31                | 6       | -        | -       |
| Ware, . . . . .                | 14                       | 8       | 9                 | -       | 1                 | 1       | -        | -       |
| Watertown, . . . . .           | 25                       | 3       | 7                 | 1       | 4                 | -       | 5        | -       |
| Wellesley, . . . . .           | 5                        | 1       | 4                 | -       | -                 | -       | 8        | -       |
| Westfield, . . . . .           | 60                       | 12      | 46                | 4       | 18                | 6       | -        | -       |
| Westford, . . . . .            | 4                        | 1       | 13                | -       | -                 | -       | 1        | -       |
| Weston, . . . . .              | 6                        | -       | -                 | -       | 8                 | -       | 1        | -       |
| Whitman, . . . . .             | 1                        | 2       | 29                | 1       | 2                 | -       | 4        | -       |
| Williamstown, . . . . .        | 10                       | 1       | 7                 | -       | 11                | 3       | -        | -       |
| Woburn, . . . . .              | 114                      | 15      | 134               | 17      | 12                | 5       | -        | -       |
| Worcester, . . . . .           | 254                      | 70      | 132               | 5       | 139               | 25      | 29       | 1       |
| Total, . . . . .               | 7,856                    | 1,484   | 6,060             | 357     | 2,665             | 459     | 5,033    | 73      |
| Fatality, per cent., . . . . . | 18.9                     |         | 5.9               |         | 17.2              |         | 1.5      |         |

Andover: small-pox, 1 case; not fatal.

The cities and towns embraced in the foregoing table are 84 in number, or 8 more than those presented in the previous year, and 1 more than those which reported for 1893. They comprise at least three-fourths of the population of the State.

The list contains the names of cities and towns containing about 15,000 more inhabitants than those which were reported last year, while one important city of about 50,000 population is omitted.

Bearing these changes in mind, the reported cases from diphtheria and croup were much in excess of those of any of the previous years embraced in the report, but the fatality (18.9) was much less. Comment upon these figures will be found elsewhere.

The reported cases of scarlet fever were considerably less than those reported in 1894, and the fatality (5.9 per cent.) was less.

The reported cases of typhoid fever were less than those of 1894, and the fatality (17.2) was but slightly greater.

The reported cases of measles were two and one-half times as many as those reported in 1894, and the fatality (1.5) was less.

The figures for 1895 are as follows:—

|                                                                                     |       |
|-------------------------------------------------------------------------------------|-------|
| Reported cases of diphtheria and croup, . . . . .                                   | 7,856 |
| Registered deaths from diphtheria and croup in the same cities and towns, . . . . . | 1,484 |
| Fatality (per cent.), . . . . .                                                     | 18.9  |
| Reported cases of scarlet fever, . . . . .                                          | 6,050 |
| Registered deaths from scarlet fever in the same cities and towns, . . . . .        | 357   |
| Fatality (per cent.), . . . . .                                                     | 5.9   |
| Reported cases of typhoid fever, . . . . .                                          | 2,665 |
| Registered deaths from typhoid fever in the same cities and towns, . . . . .        | 458   |
| Fatality (per cent.), . . . . .                                                     | 17.2  |
| Reported cases of measles, . . . . .                                                | 5,033 |
| Registered deaths from measles in the same cities and towns, . . . . .              | 75    |
| Fatality (per cent.), . . . . .                                                     | 1.5   |

The following table presents the summary of these statistics for five years 1891–1895:—

*Reported Cases of Infectious Diseases in Massachusetts.*

*Diphtheria and Croup.*

|                                 | 1891. | 1892. | 1893. | 1894. | 1895. | TOTAL. |
|---------------------------------|-------|-------|-------|-------|-------|--------|
| Reported cases, . . . . .       | 2,444 | 3,033 | 2,919 | 4,936 | 7,856 | 21,188 |
| Deaths, . . . . .               | 575   | 891   | 926   | 1,376 | 1,484 | 5,252  |
| Fatality (per cent.), . . . . . | 23.5  | 29.2  | 31.7  | 27.9  | 18.9  | 24.8   |

*Reported Cases of Infectious Diseases in Massachusetts — Concluded.**Scarlet Fever.*

|                                 | 1891. | 1892. | 1893. | 1894. | 1895. | TOTAL. |
|---------------------------------|-------|-------|-------|-------|-------|--------|
| Reported cases, . . . . .       | 4,517 | 6,112 | 7,420 | 7,416 | 6,050 | 31,515 |
| Deaths, . . . . .               | 151   | 231   | 624   | 504   | 357   | 1,917  |
| Fatality (per cent.), . . . . . | 3.3   | 4.6   | 8.8   | 6.8   | 5.9   | 6.1    |

*Typhoid Fever.*

|                                 | 1891. | 1892. | 1893. | 1894. | 1895. | TOTAL. |
|---------------------------------|-------|-------|-------|-------|-------|--------|
| Reported cases, . . . . .       | 2,414 | 1,892 | 2,457 | 2,814 | 2,065 | 12,342 |
| Deaths, . . . . .               | 460   | 435   | 492   | 483   | 456   | 2,333  |
| Fatality (per cent.), . . . . . | 19.0  | 23.0  | 20.0  | 17.0  | 17.2  | 19.1   |

*Measles.*

|                                 | 1891. | 1892. | 1893. | 1894. | 1895. | TOTAL. |
|---------------------------------|-------|-------|-------|-------|-------|--------|
| Reported cases, . . . . .       | 5,861 | 783   | 6,290 | 2,051 | 5,033 | 20,018 |
| Deaths, . . . . .               | 84    | 31    | 98    | 37    | 75    | 325    |
| Fatality (per cent.), . . . . . | 1.4   | 4.0   | 1.6   | 1.8   | 1.5   | 1.6    |

Considerable interest has been manifested recently in the mortality of cases reported as croup, but the impossibility of obtaining reliable statistics under the present system of reporting is apparent, since all reported cases of diphtheria and croup are embraced under one title in the published reports.

In England reported cases of croup have been placed in a separate list since 1892, as shown in the following table, which presents the fatality of diphtheria and croup separately. From this table it appears that the fatality from diphtheria for the three years 1892-94 was 23.3 per cent. of the reported cases, and that of croup was 40.7 per cent. The report also presents the following comment in support of the view that the fatality for croup is still greater than these figures would appear to show:—

The figures in the column of deaths from “membranous croup” do not include all the deaths which occurred from membranous croup, for, although that disease is considered to be related to diphtheria, the Registrar-

General's returns do not separate the deaths from those due to spasmodic croup, which is not a notifiable disease. It is believed, however, that in cases of membranous croup prove fatal they are often registered as diphtheria.

## ENGLAND.

[Local Government Board figures.]

|                           | DIPHTHERIA. |         | CROUP. |         | TOTAL. |         | Per Cent. |
|---------------------------|-------------|---------|--------|---------|--------|---------|-----------|
|                           | Cases.      | Deaths. | Cases. | Deaths. | Cases. | Deaths. |           |
| . . . . .                 | -           | -       | -      | -       | 2,953  | 753     | 25.5      |
| . . . . .                 | -           | -       | -      | -       | 11,919 | 2,829   | 23.7      |
| . . . . .                 | 18,977      | 3,177   | 1,169  | 401     | 15,146 | 3,578   | 23.6      |
| . . . . .                 | 20,712      | 4,751   | 1,436  | 685     | 22,148 | 5,436   | 24.5      |
| . . . . .                 | 17,581      | 4,236   | 1,256  | 486     | 18,837 | 4,722   | 25.1      |
| Total, . . . . .          | 52,270      | 12,164  | 3,861  | 1,572   | 71,003 | 17,318  | -         |
| Mean fatality, per cent., | 23.8        |         | 40.7   |         | -      |         | 24.4      |

The following figures present the fatality from diphtheria, scarlet fever and typhoid fever in England, as reported by the Local Government Board of England for the years 1890-94:—

|                          | 1890. | 1891. | 1892. | 1893. | 1894. |
|--------------------------|-------|-------|-------|-------|-------|
| diphtheria, . . . . .    | 25.5  | 23.7  | 23.6  | 24.5  | 25.1  |
| scarlet fever, . . . . . | 8.0   | 5.8   | 4.4   | 4.2   | 4.8   |
| typhoid fever, . . . . . | 19.9  | 20.8  | 17.8  | 17.0  | 17.5  |

## III.

The following summary embraces the returns of diseases "dangerous to public health" made to the State Board of Health under the provisions of chapter 302 of the Acts of 1893. Since the act in question did not specify the diseases intended to be reported to the Board (except small-pox), the Board issued a circular, in which it expressed its opinion as to the particular diseases which should be reported under the provisions of this act. They were the following: *small-pox, scarlet fever, measles, typhoid fever, diphtheria, membranous croup, cholera, yellow fever, typhus fever, cerebro-spinal meningitis, hydrophobia, malignant pustule, leprosy and trichinosis.*

The report of 1893 embraced the returns of the fractional year only which immediately followed the enactment of the statute, while those of 1894 were for a full year.

The whole number of cases of infectious diseases reported in 1895 was 21,307, which were divided as follows:—

|                                                   |        |
|---------------------------------------------------|--------|
| Reported cases of small-pox, . . . . .            | 1      |
| Reported cases of diphtheria and croup, . . . . . | 7,806  |
| Reported cases of scarlet fever, . . . . .        | 6,194  |
| Reported cases of typhoid fever, . . . . .        | 2,438  |
| Reported cases of measles, . . . . .              | 4,868  |
| Total, . . . . .                                  | 21,307 |

The summary for the years 1893, 1894 and 1895 is as follows:—

|                   | REPORTED CASES OF |                       |                |                |          |
|-------------------|-------------------|-----------------------|----------------|----------------|----------|
|                   | Small-pox.        | Diphtheria and Croup. | Scarlet Fever. | Typhoid Fever. | Measles. |
| 1893, . . . . .   | 35                | 1,109                 | 2,914          | 1,525          | 1,503    |
| 1894, . . . . .   | 181               | 4,178                 | 6,731          | 2,372          | 2,133    |
| 1895, . . . . .   | 1                 | 7,806                 | 6,194          | 2,438          | 4,868    |
| Totals, . . . . . | 217               | 13,093                | 15,839         | 6,335          | 8,504    |

*Seasonal Distribution.* — By months these diseases were reported follows in 1895 : —

*of Infectious Diseases reported to the State Board of Health by Months in 1895.*

|                 | Diphtheria<br>and Croup. | Scarlet Fever. | Typhoid<br>Fever. | Measles. |                  | Diphtheria<br>and Croup. | Scarlet Fever. | Typhoid<br>Fever. | Measles. |
|-----------------|--------------------------|----------------|-------------------|----------|------------------|--------------------------|----------------|-------------------|----------|
| January, . . .  | 631                      | 787            | 133               | 343      | August, . . .    | 497                      | 346            | 384               | 107      |
| February, . . . | 559                      | 651            | 59                | 304      | September, . . . | 566                      | 400            | 415               | 44       |
| March, . . .    | 517                      | 764            | 65                | 685      | October, . . .   | 756                      | 497            | 466               | 56       |
| April, . . .    | 341                      | 461            | 65                | 878      | November, . . .  | 1,380                    | 573            | 339               | 184      |
| May, . . .      | 389                      | 447            | 99                | 878      | December, . . .  | 1,120                    | 411            | 198               | 221      |
| June, . . .     | 614                      | 507            | 101               | 959      | Totals, . . .    | 7,806                    | 6,194          | 2,438             | 4,868    |
| July, . . .     | 436                      | 360            | 119               | 149      |                  |                          |                |                   |          |

In order that the foregoing figures may be interpreted with greater facility, the following table is appended : —

*Intensity of Prevalence.*

|                      | DIPHTHERIA AND<br>CROUP. |      | SCARLET<br>FEVER. |      | TYPHOID<br>FEVER. |      | MEASLES. |      |
|----------------------|--------------------------|------|-------------------|------|-------------------|------|----------|------|
|                      | A                        | B    | A                 | B    | A                 | B    | A        | B    |
| January, . . . . .   | 20.4                     | 9.5  | 25.4              | 14.9 | 4.3               | 6.4  | 11.1     | 8.3  |
| February, . . . . .  | 20.0                     | 9.3  | 23.2              | 13.6 | 2.1               | 3.1  | 10.9     | 8.1  |
| March, . . . . .     | 16.7                     | 7.8  | 24.3              | 14.3 | 2.1               | 3.1  | 22.1     | 16.5 |
| April, . . . . .     | 11.4                     | 5.3  | 15.4              | 9.0  | 2.2               | 3.3  | 29.2     | 21.8 |
| May, . . . . .       | 12.5                     | 5.8  | 14.4              | 8.5  | 3.2               | 4.8  | 28.3     | 21.1 |
| June, . . . . .      | 20.5                     | 9.6  | 16.9              | 9.9  | 3.4               | 5.1  | 32.0     | 23.9 |
| July, . . . . .      | 14.1                     | 6.6  | 11.6              | 6.8  | 3.8               | 5.7  | 4.8      | 3.6  |
| August, . . . . .    | 16.0                     | 7.5  | 11.2              | 6.6  | 12.4              | 18.5 | 3.4      | 2.6  |
| September, . . . . . | 18.9                     | 8.8  | 13.3              | 7.8  | 13.8              | 20.6 | 1.5      | 1.1  |
| October, . . . . .   | 24.4                     | 11.4 | 16.0              | 9.4  | 15.0              | 22.4 | 1.8      | 1.3  |
| November, . . . . .  | 46.0                     | 21.5 | 19.1              | 11.2 | 11.3              | 16.9 | 6.1      | 4.6  |
| December, . . . . .  | 36.1                     | 16.9 | 13.3              | 7.8  | 6.2               | 9.2  | 9.1      | 6.8  |
| Mean, . . . . .      | 21.4                     | 10.0 | 17.0              | 10.0 | 6.7               | 10.0 | 13.4     | 10.0 |

The figures in the foregoing table are introduced for the purpose, of comparing the prevalence of one disease with another, but the purpose of presenting the reports of each month upon a uni-

form basis of comparison, month by month, so that the relative intensity of each disease is shown for each month. The method also has the advantage of eliminating the apparent errors of computation arising from the unequal length of the months.

The figures may be read as follows: for example, the mean daily number of reported cases of diphtheria and croup in January was 20.4; of scarlet fever, 25.4; of typhoid fever, 4.3; and of measles, 11.1 (see columns marked A); and the mean daily number of the same diseases for the whole year 1895 was, respectively, 21.4—, 17.0—, 6.7 and 13.4. Assuming a standard of 10 as the daily mean of each disease for the year, the ratios for January were as follows: diphtheria and croup, 9.5; scarlet fever, 14.9; typhoid fever, 6.4; and measles, 8.3. (See columns marked B.) That is to say, for each 10 reported cases of diphtheria and croup occurring throughout the year, as a daily mean, there were 9.5 daily in January, 9.3 in February, etc.

The following table presents the numbers of cases of each disease reported from each city and town in 1895. The whole number of reporting cities and towns is less than that of the previous year; but, while the number of small towns reporting is less, the number of towns having over 5,000 population is greater.

Where the name of a city or town occurs both in Section II. and in Section III. of this summary, the difference in numbers may be taken as the deficiency in returns made by the local board to the State Board of Health.

*Cases of Infectious Diseases reported to the State Board of Health from One Hundred and Fifty-five Cities and Towns during 1895*

|                   | Diphtheria. | Scarlet Fever. | Typhoid Fever. | Measles. |                     | Diphtheria. | Scarlet Fever. | Typhoid Fever. | Measles. |
|-------------------|-------------|----------------|----------------|----------|---------------------|-------------|----------------|----------------|----------|
| Aceusnet, . . .   | -           | 4              | -              | -        | Attleborough, . . . | 4           | 13             | 3              | 2        |
| Adams, . . .      | 2           | 6              | -              | 2        | Auburn, . . .       | -           | 1              | -              | -        |
| Agawam, . . .     | -           | 2              | -              | -        | Ayer, . . .         | 3           | 36             | 6              | -        |
| Amesbury, . . .   | 23          | 68             | 16             | 162      | Barnstable, . . .   | 3           | 6              | -              | 1        |
| Amherst, . . .    | -           | 5              | 3              | -        | Bedford, . . .      | 2           | 10             | -              | 2        |
| Arlington, . . .  | 22          | 18             | 3              | -        | Belchertown, . . .  | 1           | 2              | -              | 2        |
| Ashburnham, . . . | 1           | -              | -              | -        | BEVERLY, . . .      | 60          | 40             | 17             | 4        |
| Ashland, . . .    | 2           | 1              | -              | 1        | BillERICA, . . .    | -           | 3              | -              | -        |
| Athol, . . .      | 1           | 1              | -              | -        | Bolton, . . .       | 5           | -              | 2              | 1        |

*Cases of Infectious Diseases, etc. — Continued.*

|               | Diphtheria. | Scarlet Fever. | Typhoid Fever. | Measles. |                  | Diphtheria. | Scarlet Fever. | Typhoid Fever. | Measles. |
|---------------|-------------|----------------|----------------|----------|------------------|-------------|----------------|----------------|----------|
| N, . . .      | 4,150       | 1,099          | 994            | 2,657    | Hampden, . .     | -           | 1              | -              | -        |
| ord, . .      | 4           | 8              | 7              | 19       | Hanson, . . .    | -           | 4              | -              | -        |
| ree, . .      | 1           | -              | -              | -        | Hardwick, . .    | 22          | 1              | -              | -        |
| water, . .    | -           | 5              | -              | -        | Harvard, . . .   | 1           | 15             | 2              | -        |
| eld, . .      | 1           | 10             | 16             | 19       | HAVERHILL, . .   | 28          | 99             | 39             | 219      |
| TON, . .      | 32          | 153            | 9              | 2        | Hingham, . .     | 1           | 9              | -              | -        |
| line, . .     | 84          | 32             | -              | -        | Hinsdale, . .    | -           | 3              | 1              | 9        |
| HIDGE, . .    | 623         | 289            | 116            | 249      | Holliston, . .   | 4           | 25             | -              | 25       |
| l, . . .      | 3           | 1              | -              | -        | Hudson, . . .    | 1           | -              | -              | -        |
| e, . . .      | -           | 1              | -              | -        | Hull, . . .      | 2           | -              | -              | -        |
| , . . .       | 9           | -              | -              | -        | Ipawich, . . .   | 14          | 42             | 7              | 77       |
| sford, . .    | -           | 17             | 2              | -        | Kingston, . .    | -           | 7              | -              | 1        |
| EA, . .       | 180         | 128            | 6              | 23       | Lancaster, . .   | -           | -              | 4              | 46       |
| l, . . .      | 1           | 3              | -              | -        | LAWRENCE, . .    | 38          | 109            | 62             | 151      |
| rd, . . .     | 8           | 18             | 8              | 1        | Leicester, . .   | 9           | 4              | -              | -        |
| y, . . .      | -           | 6              | 1              | 179      | Lenox, . . .     | 7           | 1              | 4              | -        |
| rs, . . .     | 2           | 33             | 3              | 51       | Leominster, . .  | -           | 12             | 2              | 2        |
| m, . . .      | 46          | 54             | 1              | 11       | Leyden, . . .    | 4           | -              | -              | -        |
| n, . . .      | 11          | 2              | -              | -        | Lexington, . .   | 1           | 4              | -              | 3        |
| . . .         | -           | 3              | -              | -        | Lincoln, . . .   | 6           | 4              | -              | 1        |
| r, . . .      | 1           | 7              | -              | -        | Lunenburg, . .   | 2           | 8              | -              | -        |
| ry, . . .     | 1           | 2              | -              | -        | LYNN, . . .      | 222         | 382            | 104            | 158      |
| ridgewater, . | -           | 18             | -              | -        | MALDEN, . . .    | 49          | 40             | 29             | 26       |
| mpton, . .    | -           | 23             | 2              | 32       | MARLBOROUGH, .   | 5           | 2              | -              | 109      |
| ongmeadow, .  | -           | 13             | -              | -        | Manchester, . .  | 2           | 5              | 1              | -        |
| , . . .       | 1           | 5              | -              | -        | Marshfield, . .  | 1           | 3              | -              | -        |
| TT, . . .     | 44          | 49             | 23             | 45       | Maynard, . .     | -           | 1              | -              | -        |
| ven, . . .    | -           | 5              | -              | -        | MEDFORD, . .     | 40          | 76             | 26             | 18       |
| RIVER, . .    | 54          | 166            | 84             | -        | Melrose, . . .   | 3           | 9              | 5              | 8        |
| SURG, . .     | 27          | 44             | 35             | 15       | Middleborough, . | 9           | 37             | 4              | -        |
| ough, . .     | 48          | 21             | 1              | -        | Millford, . . .  | 21          | 22             | 3              | -        |
| ln, . . .     | 36          | -              | 4              | 70       | Millbury, . . .  | 4           | 11             | 2              | 2        |
| BETER, . .    | 156         | 155            | 25             | -        | Milton, . . .    | 18          | 5              | 13             | 7        |
| s, . . .      | -           | 16             | 1              | 2        | Montague, . .    | 3           | 2              | 8              | -        |
| lle, . . .    | 1           | 1              | -              | -        | Nantucket, . .   | 2           | -              | -              | -        |
| and, . .      | 1           | 4              | -              | -        | NEW BEDFORD, .   | 139         | 94             | 78             | 18       |



*Cases of Infectious Diseases, etc. — Concluded.*

|                         | Diphtheria. | Scarlet Fever. | Typhoid Fever. | Measles. |                      | Diphtheria. | Scarlet Fever | Typhoid Fever | Measles. |
|-------------------------|-------------|----------------|----------------|----------|----------------------|-------------|---------------|---------------|----------|
| NEWBURYPORT, . . .      | 9           | 59             | 27             | -        | Somerset, . . .      | -           | 2             | -             | -        |
| NEWTON, . . .           | 131         | 91             | 18             | 250      | SOMERVILLE, . . .    | 238         | 230           | 38            | -        |
| NORTH ADAMS, . . .      | 24          | 12             | 38             | 2        | Southampton, . . .   | 1           | 1             | -             | -        |
| NORTHAMPTON, . . .      | 5           | 27             | 48             | 10       | SPRINGFIELD, . . .   | 47          | 111           | 41            | 53       |
| North Andover, . . .    | -           | 19             | -              | 8        | Sterling, . . .      | -           | -             | 1             | -        |
| No. Attleborough, . . . | 7           | 18             | -              | -        | Stow, . . .          | 1           | -             | 1             | -        |
| Northborough, . . .     | 8           | -              | -              | -        | Sutton, . . .        | -           | 3             | -             | -        |
| Northbridge, . . .      | 1           | 25             | -              | -        | Swampscott, . . .    | 7           | 6             | 1             | 1        |
| North Brookfield, . . . | -           | 2              | 2              | -        | TAUNTON, . . .       | 186         | 37            | 3             | -        |
| Norton, . . .           | -           | 5              | -              | -        | Templeton, . . .     | -           | 1             | -             | -        |
| Orange, . . .           | 1           | 1              | 18             | 3        | Tolland, . . .       | -           | -             | 1             | -        |
| Oxford, . . .           | -           | 3              | 1              | 20       | Upton, . . .         | -           | -             | 1             | -        |
| Palmer, . . .           | 6           | 68             | 7              | -        | WALTHAM, . . .       | 177         | 68            | 25            | -        |
| Paxton, . . .           | -           | 1              | -              | -        | Ware, . . .          | 7           | 9             | 1             | -        |
| Peabody, . . .          | 10          | 186            | 34             | -        | Warren, . . .        | 1           | 14            | 3             | 1        |
| Pepperell, . . .        | 1           | 8              | 1              | 1        | Watertown, . . .     | 22          | 7             | 4             | 1        |
| PITTSFIELD, . . .       | 2           | 8              | 1              | 4        | Webster, . . .       | 5           | 4             | 10            | -        |
| Plymouth, . . .         | 9           | 51             | 20             | 3        | Wenham, . . .        | 1           | -             | -             | -        |
| Princeton, . . .        | 15          | 1              | -              | 3        | West Boylston, . . . | 2           | 35            | 1             | -        |
| QUINCY, . . .           | 109         | 59             | 21             | 30       | Westfield, . . .     | 50          | 45            | 13            | -        |
| Randolph, . . .         | 7           | 13             | -              | 1        | Westford, . . .      | 1           | 18            | -             | 1        |
| Raynham, . . .          | 6           | -              | -              | -        | Westminster, . . .   | -           | 8             | 1             | -        |
| Reading, . . .          | 7           | 4              | 34             | 3        | Weston, . . .        | 6           | -             | 7             | 1        |
| Revere, . . .           | 26          | 20             | 2              | -        | Weymouth, . . .      | 18          | 42            | 2             | -        |
| Rockland, . . .         | -           | 42             | -              | -        | Whitman, . . .       | 1           | 40            | -             | 1        |
| Rockport, . . .         | 5           | 2              | 33             | -        | Williamstown, . . .  | 4           | 6             | 9             | -        |
| Rowley, . . .           | 1           | 25             | 6              | 2        | Winchendon, . . .    | 14          | 2             | 4             | -        |
| SALEM, . . .            | 45          | 267            | 34             | -        | Winchester, . . .    | -           | 2             | 1             | 1        |
| Sandisfield, . . .      | -           | -              | 9              | -        | Winthrop, . . .      | 17          | 3             | 2             | -        |
| Scituate, . . .         | 2           | 2              | -              | -        | WOBURN, . . .        | 79          | 113           | 4             | -        |
| Saugus, . . .           | 14          | 18             | 6              | 1        | WORCESTER, . . .     | 250         | 146           | 123           | 23       |
| Sharon, . . .           | -           | 1              | -              | -        | Wrentham, . . .      | 4           | 1             | -             | -        |
| Sherborn, . . .         | 4           | 7              | -              | 2        | Totals, . . .        | 7,806       | 6,194         | 2,438         | 4,566    |

One case of small-pox in Andover.

The following list comprises the cities and towns which failed to report (under the provisions of the statute) to the State Board of

Health. It is but just to state that in many of the towns named in group IV. and in some of those in group III. it is quite probable that no cases of infectious disease occurred.

# LIST OF TOWNS FROM WHICH NO REPORTS WERE RECEIVED.

## I. Cities.

CHICOPEE, HOLYOKE.

## II. Towns having a Population of More than 5,000 in Each.

|             |              |                         |
|-------------|--------------|-------------------------|
| Andover,    | Marblehead,  | Stoughton,              |
| Blackstone, | Methuen,     | Wakefield,              |
| Gardner,    | Southbridge, | Westborough,            |
| Greenfield, | Spencer,     | West Springfield. — 14. |
| Hyde Park,  | Stoneham,    |                         |

## II. Towns having a Population of Over 1,000 but Less than 5,000 in Each.

|                   |                  |                   |
|-------------------|------------------|-------------------|
| Abington,         | Groton,          | Rochester,        |
| Acton,            | Hadley,          | Salisbury,        |
| Ashfield,         | Hamilton,        | Sandwich,         |
| Avon,             | Hanover,         | Seekonk,          |
| Barre,            | Harwich,         | Sheffield,        |
| Bellingham,       | Hatfield,        | Shelburne,        |
| Belmont,          | Holbrook,        | Shirley,          |
| Brookfield,       | Holden,          | Shrewsbury,       |
| Buckland,         | Hopedale,        | Southborough,     |
| Charlemont,       | Hopkinton,       | South Hadley,     |
| Charlton,         | Hubbardston,     | Stockbridge,      |
| Chatham,          | Huntington,      | Sturbridge,       |
| Cheshire,         | Lee,             | Sudbury,          |
| Chester,          | Lexington,       | Swansea,          |
| Clarksburg,       | Littleton,       | Tewksbury,        |
| Cohasset,         | Ludlow,          | Tisbury,          |
| Colrain,          | Mansfield,       | Topsfield,        |
| Cottage City,     | Mattapoisett,    | Townsend,         |
| Dalton,           | Medfield,        | Uxbridge,         |
| Dartmouth,        | Medway,          | Walpole,          |
| Deerfield,        | Merrimac,        | Wareham,          |
| Dennis,           | Millis,          | Wayland,          |
| Douglas,          | Monson,          | Wellesley,        |
| Dracut,           | Needham,         | West Bridgewater, |
| Easthampton,      | Newbury,         | West Brookfield,  |
| Easton,           | New Marlborough, | West Newbury,     |
| Edgartown,        | Northfield,      | Westport,         |
| Essex,            | Norwell,         | West Stockbridge, |
| Falmouth,         | Norwood,         | Wilbraham,        |
| Freetown,         | Orleans,         | Williamsburg,     |
| Georgetown,       | Pembroke,        | Wilmington,       |
| Gill,             | Provincetown,    | Yarmouth. — 98.   |
| Great Barrington, | Rehoboth,        |                   |

LIST OF TOWNS FROM WHICH NO REPORTS WERE RECEIVED — *Concluded.**IV. Towns having Less than 1,000 Inhabitants.*

|               |                   |                    |
|---------------|-------------------|--------------------|
| Alford,       | Hancock,          | Petersham,         |
| Ashby,        | Hawley,           | Phillipston,       |
| Becket,       | Heath,            | Plainfield,        |
| Berkley,      | Holland,          | Plympton,          |
| Berlin,       | Lakeville,        | Prescott,          |
| Bernardston,  | Lanesborough,     | Richmond,          |
| Blandford,    | Leverett,         | Rowe,              |
| Boxborough,   | Longmeadow,       | Royalston,         |
| Boxford,      | Lynnfield,        | Russell,           |
| Boylston,     | Marion,           | Rutland,           |
| Brewster,     | Mashpee,          | Savoy,             |
| Burlington,   | Mendon,           | Shutesbury,        |
| Chesterfield, | Middlefield,      | Southwick,         |
| Chilmark,     | Middleton,        | Sunderland,        |
| Cummington,   | Munroe,           | Truro,             |
| Dana,         | Monterey,         | Tyngsborough,      |
| Dover,        | Montgomery,       | Tyringham,         |
| Dunstable,    | Mount Washington, | Wales,             |
| Eastham,      | Nahant,           | Warwick,           |
| Egremont,     | New Ashford,      | Washington,        |
| Enfield,      | New Braintree,    | Wellfleet,         |
| Florida,      | New Salem,        | Wendell,           |
| Gay Head,     | Norfolk,          | Westhampton,       |
| Gosnold,      | North Reading,    | West Tisbury,      |
| Goshen,       | Oakham,           | Whately,           |
| Granby,       | Otis,             | Windsor,           |
| Greenwich,    | Pelham,           | Worthington. — 83. |
| Halifax,      | Peru,             |                    |

The Board will forward to the local board of health of any place the postal cards necessary for reporting on application from such local board of health.

## IV.

The following summary comprises the results obtained from the tabulation of the returns required by chapter 218 of the Acts of 1894, whereby the board of health of each city and populous town is directed to send to the State Board of Health an annual statement of the deaths in such city or town upon a blank form furnished by the State Board.

The whole number of cities and towns included in this list is eighty-five, of which number eighty complied with the statute. The total population of these cities and towns by the census of 1895 was 1,971,817. The number of deaths registered in these cities and towns was 37,828, and the death rate was 19.18 per 1,000.

*Sexes.* — The number of deaths of males was 19,109, or 50.5 per cent. of the whole number of deaths; and the deaths of females were 8,702, or 49.5 per cent.

*Ages.* — The deaths of infants under one were 8,634, or 22.8 per cent. of the total mortality; those of children under five years of age were 12,425, or 32.8 per cent. of the whole.

In conformity with the age distribution recommended by Körösi, the deaths of those whose ages were known were as follows: —

| AGES.                   | Percentages. | AGES.                  | Percentages. |
|-------------------------|--------------|------------------------|--------------|
| Under 1 year, . . . . . | 22.9         | 20-50, . . . . .       | 25.7         |
| 1-20, . . . . .         | 17.9         | All over 50, . . . . . | 33.5         |

*Months and Quarters.* — The number of deaths in each quarter of the year is shown in the following table: —

|                           | Deaths. | Percentages. |                           | Deaths. | Percentages. |
|---------------------------|---------|--------------|---------------------------|---------|--------------|
| First quarter, . . . . .  | 10,181  | 26.9         | Fourth quarter, . . . . . | 8,712   | 23.0         |
| Second quarter, . . . . . | 8,566   | 22.7         | Date unknown, . . . . .   | 10      | —            |
| Third quarter, . . . . .  | 10,359  | 27.4         | Total, . . . . .          | 37,828  | 100.0        |

The intensity of the seasonal death rate is shown in the following table, the method employed being explained on page 730, in Section III., relating to disease notification.

*Seasonal Intensity of the Death Rate.*

|                   | Mean Daily Deaths per Month. | Mean Rate compared with a Standard of 100. |                    | Mean Daily Deaths per Month. | Mean Rate compared with a Standard of 100. |
|-------------------|------------------------------|--------------------------------------------|--------------------|------------------------------|--------------------------------------------|
| January, . . . .  | 99.7                         | 96.2                                       | August, . . . .    | 126.4                        | 122.0                                      |
| February, . . . . | 125.1                        | 120.8                                      | September, . . . . | 109.6                        | 105.3                                      |
| March, . . . .    | 115.7                        | 111.7                                      | October, . . . .   | 95.0                         | 91.7                                       |
| April, . . . .    | 105.5                        | 101.8                                      | November, . . . .  | 94.8                         | 91.5                                       |
| May, . . . .      | 93.1                         | 89.9                                       | December, . . . .  | 94.4                         | 91.1                                       |
| June, . . . .     | 88.8                         | 80.9                                       | Annual mean, . .   | 103.6                        | 100.0                                      |
| July, . . . .     | 101.7                        | 98.2                                       |                    |                              |                                            |

*Causes of Death.*—The list of causes of death embraced in this summary includes those from the principal infectious diseases, including consumption, together with certain other groups of destructive diseases and those from violence.

The ratio of deaths to the living population is also presented, since this method of presentation, especially in a census year, constitutes a better method of indicating the incidence of each cause of death upon the living population than the ratio of the deaths from each disease or cause of death to the total mortality.

TABLE I.

| REPORTING CITIES AND TOWNS. | Population, 1895.<br>(State Census.) | REPORTING CITIES AND TOWNS.   | Population, 1895.<br>(State Census.) |
|-----------------------------|--------------------------------------|-------------------------------|--------------------------------------|
| Adams, . . . .              | 7,837                                | CHICOPEE, . . . .             | 16,420                               |
| Amesbury, . . . .           | 9,986                                | Clinton, . . . .              | 11,497                               |
| Andover, . . . .            | 6,145                                | Concord, . . . .              | 5,175                                |
| Arlington, . . . .          | 6,515                                | Danvers, . . . .              | 8,181                                |
| Athol, . . . .              | 7,364                                | Danvers Lunatic Hospital, . . | -                                    |
| Attleborough, . . . .       | 8,288                                | Dedham, . . . .               | 7,211                                |
| BEVERLY, . . . .            | 11,806                               | EVERETT, . . . .              | 18,573                               |
| Blackstone, . . . .         | 6,039                                | FALL RIVER, . . . .           | 89,203                               |
| BOSTON, . . . .             | 496,920                              | FITCHBURG, . . . .            | 26,400                               |
| Braintree, . . . .          | 5,311                                | Frammingham, . . . .          | 9,512                                |
| BROCKTON, . . . .           | 33,165                               | Franklin, . . . .             | 5,136                                |
| Brookline, . . . .          | 16,164                               | Gardner, . . . .              | 9,192                                |
| CAMBRIDGE, . . . .          | 81,643                               | GLOUCESTER, . . . .           | 23,211                               |
| CHELSEA, . . . .            | 31,264                               | Greenfield, . . . .           | 6,229                                |

TABLE I — *Concluded.*

| REPORTING CITIES AND TOWNS. | Population,<br>1895.<br>(State Census.) | REPORTING CITIES AND TOWNS. | Population,<br>1895.<br>(State Census.) |
|-----------------------------|-----------------------------------------|-----------------------------|-----------------------------------------|
| ASHILL, . . . . .           | 20,209                                  | PITTSFIELD, . . . . .       | 20,461                                  |
| ASHMUN, . . . . .           | 5,308                                   | Plymouth, . . . . .         | 7,967                                   |
| ASH PARK, . . . . .         | 11,826                                  | QUINCY, . . . . .           | 20,712                                  |
| ASH PENCE, . . . . .        | 52,164                                  | Revere, . . . . .           | 7,423                                   |
| ASH PATER, . . . . .        | 9,211                                   | Rockland, . . . . .         | 5,523                                   |
| ASH PELL, . . . . .         | 84,367                                  | Rockport, . . . . .         | 5,289                                   |
| ASH P, . . . . .            | 62,354                                  | SALEM, . . . . .            | 34,473                                  |
| ASH EN, . . . . .           | 29,708                                  | SOMERVILLE, . . . . .       | 52,200                                  |
| ASH PHEAD, . . . . .        | 7,671                                   | Southbridge, . . . . .      | 8,250                                   |
| ASH BOROUGH, . . . . .      | 14,977                                  | Spencer, . . . . .          | 7,614                                   |
| ASH ORD, . . . . .          | 14,474                                  | SPRINGFIELD, . . . . .      | 51,522                                  |
| ASH P, . . . . .            | 11,965                                  | Stoneham, . . . . .         | 6,284                                   |
| ASH EN, . . . . .           | 5,690                                   | Stoughton, . . . . .        | 5,272                                   |
| ASH BOROUGH, . . . . .      | 6,689                                   | TAUNTON, . . . . .          | 27,115                                  |
| ASH D, . . . . .            | 8,959                                   | Wakefield, . . . . .        | 8,304                                   |
| ASH TRY, . . . . .          | 5,222                                   | WALTHAM, . . . . .          | 20,876                                  |
| ASH P, . . . . .            | 5,518                                   | Ware, . . . . .             | 7,651                                   |
| ASH T, . . . . .            | 8,951                                   | Watertown, . . . . .        | 7,788                                   |
| BEDFORD, . . . . .          | 55,251                                  | Webster, . . . . .          | 7,799                                   |
| BURYPORT, . . . . .         | 14,552                                  | Westfield, . . . . .        | 10,663                                  |
| BURTON, . . . . .           | 27,590                                  | Weymouth, . . . . .         | 11,291                                  |
| B. E. ADAMS, . . . . .      | 19,135                                  | Whitman, . . . . .          | 5,744                                   |
| B. HAMPTON, . . . . .       | 16,746                                  | Winchester, . . . . .       | 6,150                                   |
| B. Attleborough, . . . . .  | 6,576                                   | WOBURN, . . . . .           | 14,178                                  |
| B. bridge, . . . . .        | 5,286                                   | WORCESTER, . . . . .        | 98,767                                  |
| B. C, . . . . .             | 5,361                                   |                             |                                         |
| B. R, . . . . .             | 6,858                                   | Total, . . . . .            | 1,971,817                               |
| B. DY, . . . . .            | 10,507                                  |                             |                                         |

Grafton, Holyoke, Montague, Westborough and West Springfield, no returns.

TABLE II.

*Total Deaths, Deaths by Sexes and Age Periods, and Still-births in Cities and Towns having over 5,000 Inhabitants in Each, by Census of 1895.*

|                         | Total Deaths. | Males. | Females. | Sex Unknown. | Still-births. | Deaths Under 1. | 1-2. | 2-3. | 3-4. | 4-5. | 5-10. | 10-15. | 15-20. | 20-30. | 30-40. | 40-50. | 50-60. | 60-70. | 70-80. | Over 80. | Age Unknown. | Rate per 1,000. |
|-------------------------|---------------|--------|----------|--------------|---------------|-----------------|------|------|------|------|-------|--------|--------|--------|--------|--------|--------|--------|--------|----------|--------------|-----------------|
| Adams, . . . . .        | 129           | 66     | 63       | -            | 4             | 34              | 5    | 2    | -    | 3    | 5     | 3      | 6      | 14     | 7      | 7      | 7      | 11     | 16     | 8        | -            | 16.46           |
| Amesbury, . . . . .     | 171           | 73     | 98       | -            | 8             | 25              | 9    | 5    | -    | -    | 7     | 4      | 2      | 15     | 9      | 12     | 21     | 19     | 20     | 19       | 4            | 17.12           |
| Andover, . . . . .      | 103           | 58     | 45       | -            | 1             | 14              | 3    | 1    | 1    | 1    | 1     | -      | 9      | 5      | 6      | 5      | 10     | 10     | 20     | 16       | 2            | 16.76           |
| Arlington, . . . . .    | 97            | 51     | 46       | -            | 7             | 14              | 7    | -    | 3    | 4    | 1     | 1      | 4      | 9      | 9      | 6      | 5      | 13     | 12     | 9        | -            | 14.89           |
| Athol, . . . . .        | 92            | 47     | 45       | -            | 3             | 22              | 5    | 1    | 1    | 1    | 1     | 1      | 2      | 6      | 9      | 5      | 8      | 6      | 16     | 8        | -            | 12.49           |
| Attleborough, . . . . . | 127           | 70     | 57       | -            | 5             | 23              | 3    | 1    | 3    | -    | 1     | 3      | 6      | 14     | 9      | 8      | 13     | 10     | 19     | 13       | 1            | 15.32           |
| Beverly, . . . . .      | 191           | 89     | 101      | 1            | 13            | 29              | 10   | 2    | 3    | 1    | 10    | 5      | 2      | 15     | 17     | 12     | 15     | 29     | 24     | 25       | 1            | 16.18           |
| Blackstone, . . . . .   | 134           | 81     | 53       | -            | 4             | 22              | 4    | 5    | 4    | 1    | 1     | -      | 2      | 20     | 11     | 7      | 18     | 13     | 8      | 7        | 11           | 22.19           |
| Boston, . . . . .       | 11,329        | 5,831  | 5,498    | -            | 607           | 2,680           | 689  | 306  | 198  | 162  | 356   | 103    | 299    | 1,122  | 1,154  | 1,062  | 1,015  | 982    | 834    | 407      | -            | 22.88           |
| Braintree, . . . . .    | 82            | 40     | 42       | -            | 1             | 13              | 5    | 4    | 4    | 3    | 3     | 1      | -      | 2      | 5      | 6      | 3      | 13     | 10     | 10       | -            | 15.44           |

| Danvers Lunatic Hospital. |       |     | No. | 1866 | 1867 | 1868 | 1869 | 1870 | 1871 | 1872 | 1873 | 1874 | 1875 | 1876 | 1877 | 1878 | 1879 | 1880 | 1881 | 1882 | 1883 | 1884  | 1885  | 1886 | 1887 | 1888 | 1889 | 1890  | 1891  | 1892 | 1893 | 1894 | 1895 | 1896 | 1897 | 1898 | 1899 | 1900 |   |
|---------------------------|-------|-----|-----|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------|-------|------|------|------|------|-------|-------|------|------|------|------|------|------|------|------|------|---|
| Dedham, . . . . .         | 145   | 79  | 66  | -    | 6    | 18   | 6    | 2    | 4    | 1    | 5    | 2    | 3    | 14   | 6    | 8    | 12   | 8    | 2    | 3    | 14   | 6     | 8     | 14   | 25   | 20   | 17   | -     | 20.11 | -    | 8    | 1    | -    | -    | -    | -    | -    | -    | - |
| EVERETT, . . . . .        | 276   | 134 | 142 | -    | 17   | 74   | 20   | 9    | 5    | 7    | 8    | 2    | 1    | 24   | 24   | 26   | 26   | 25   | 13   | 23   | 16   | -     | 14.86 | -    | 25   | 20   | 17   | -     | 20.11 | -    | 8    | 1    | -    | -    | -    | -    | -    | -    | - |
| FALL RIVER, . . . . .     | 1,902 | 997 | 905 | -    | 169  | 688  | †    | †    | †    | †    | 68   | †    | †    | 164  | 123  | 115  | 144  | 144  | 131  | 71   | 43   | -     | 21.32 | -    | 25   | 20   | 17   | -     | 20.11 | -    | 8    | 1    | -    | -    | -    | -    | -    | -    | - |
| FITCHBURG, . . . . .      | 403   | 192 | 211 | -    | 29   | 121  | 17   | 5    | 4    | 6    | 12   | 5    | 11   | 34   | 26   | 27   | 26   | 26   | 42   | 45   | 22   | -     | 15.26 | -    | 25   | 20   | 17   | -     | 20.11 | -    | 8    | 1    | -    | -    | -    | -    | -    | -    | - |
| Framingham, . . . . .     | 148   | 76  | 72  | -    | 8    | 28   | 2    | 2    | 3    | -    | 1    | 3    | 3    | 11   | 14   | 10   | 14   | 11   | 25   | 25   | 2    | -     | 15.56 | -    | 25   | 20   | 17   | -     | 20.11 | -    | 8    | 1    | -    | -    | -    | -    | -    | -    | - |
| Franklin, . . . . .       | 86    | 44  | 42  | -    | 1    | 11   | 3    | 2    | 4    | 1    | 5    | 1    | -    | 6    | 4    | 6    | 3    | 15   | 19   | 6    | -    | 16.75 | -     | 25   | 20   | 17   | -    | 20.11 | -     | 8    | 1    | -    | -    | -    | -    | -    | -    | -    |   |
| Gardner, . . . . .        | 177   | 111 | 66  | -    | 19   | 45   | 5    | 3    | 4    | 3    | 3    | 2    | 3    | 19   | 15   | 9    | 5    | 19   | 24   | 18   | -    | 19.28 | -     | 25   | 20   | 17   | -    | 20.11 | -     | 8    | 1    | -    | -    | -    | -    | -    | -    | -    |   |
| GLOUCESTER*, . . . . .    | 423   | 205 | 217 | 1    | 34   | 119  | 20   | 14   | 4    | 6    | 15   | 8    | 10   | 45   | 25   | 27   | 29   | 33   | 42   | 26   | 1    | -     | 14.99 | -    | 25   | 20   | 17   | -     | 20.11 | -    | 8    | 1    | -    | -    | -    | -    | -    | -    | - |
| Greenfield, . . . . .     | 93    | 45  | 48  | -    | 3    | 11   | 1    | 2    | 1    | -    | -    | -    | -    | 9    | 9    | 7    | 9    | 19   | 15   | 9    | -    | 14.93 | -     | 25   | 20   | 17   | -    | 20.11 | -     | 8    | 1    | -    | -    | -    | -    | -    | -    | -    |   |
| HAYVERHILL, . . . . .     | 521   | 242 | 279 | -    | 31   | 125  | 17   | 17   | 6    | 6    | 18   | 6    | 7    | 47   | 50   | 29   | 51   | 53   | 47   | 42   | -    | 17.25 | -     | 25   | 20   | 17   | -    | 20.11 | -     | 8    | 1    | -    | -    | -    | -    | -    | -    | -    |   |
| Hudson, . . . . .         | 82    | 45  | 36  | 1    | 2    | 18   | 8    | 1    | -    | -    | 2    | 1    | 2    | 7    | 3    | 6    | 2    | 13   | 9    | 10   | -    | 15.45 | -     | 25   | 20   | 17   | -    | 20.11 | -     | 8    | 1    | -    | -    | -    | -    | -    | -    | -    |   |
| Hyde Park, . . . . .      | 203   | 103 | 100 | -    | 14   | 44   | 12   | 3    | 6    | 5    | 7    | 2    | 4    | 19   | 21   | 12   | 13   | 22   | 20   | 13   | -    | 17.17 | -     | 25   | 20   | 17   | -    | 20.11 | -     | 8    | 1    | -    | -    | -    | -    | -    | -    | -    |   |
| LAWRENCE, . . . . .       | 1,044 | 512 | 530 | 2    | 69   | 310  | 66   | 23   | 11   | 7    | 18   | 12   | 38   | 118  | 79   | 78   | 80   | 100  | 62   | 36   | 6    | -     | 20.01 | -    | 25   | 20   | 17   | -     | 20.11 | -    | 8    | 1    | -    | -    | -    | -    | -    | -    | - |
| Leominster, . . . . .     | 138   | 66  | 72  | -    | 5    | 23   | 2    | 2    | -    | -    | 1    | 3    | 3    | 17   | 9    | 9    | 19   | 21   | 14   | 16   | -    | 14.98 | -     | 25   | 20   | 17   | -    | 20.11 | -     | 8    | 1    | -    | -    | -    | -    | -    | -    | -    |   |
| LOWELL, . . . . .         | 1,857 | 943 | 914 | -    | 170  | 566  | 123  | 49   | 28   | 22   | 40   | 26   | 47   | 172  | 169  | 142  | 141  | 180  | 141  | 61   | -    | 22.01 | -     | 25   | 20   | 17   | -    | 20.11 | -     | 8    | 1    | -    | -    | -    | -    | -    | -    | -    |   |
| LYNN, . . . . .           | 1,086 | 523 | 563 | -    | 52   | 214  | 42   | 18   | 18   | 20   | 54   | 31   | 29   | 97   | 100  | 80   | 115  | 94   | 100  | 82   | 2    | -     | 17.42 | -    | 25   | 20   | 17   | -     | 20.11 | -    | 8    | 1    | -    | -    | -    | -    | -    | -    | - |
| MALDEN, . . . . .         | 507   | 247 | 260 | -    | 47   | 74   | 36   | 12   | 8    | 4    | 20   | 7    | 15   | 53   | 42   | 39   | 38   | 68   | 54   | 37   | -    | 17.07 | -     | 25   | 20   | 17   | -    | 20.11 | -     | 8    | 1    | -    | -    | -    | -    | -    | -    | -    |   |
| Marblehead, . . . . .     | 152   | 81  | 71  | -    | 4    | 21   | 4    | 2    | 3    | 2    | 6    | 2    | 4    | 6    | 9    | 8    | 20   | 23   | 23   | 19   | -    | 19.81 | -     | 25   | 20   | 17   | -    | 20.11 | -     | 8    | 1    | -    | -    | -    | -    | -    | -    | -    |   |
| MARLBOROUGH, . . . . .    | 263   | 138 | 125 | -    | 8    | 63   | 13   | 8    | -    | 5    | 4    | 3    | 9    | 28   | 21   | 21   | 29   | 23   | 25   | 11   | -    | 17.56 | -     | 25   | 20   | 17   | -    | 20.11 | -     | 8    | 1    | -    | -    | -    | -    | -    | -    | -    |   |
| MEDFORD, . . . . .        | 206   | 106 | 99  | 1    | 9    | 39   | 5    | 3    | 3    | 4    | 6    | 5    | 4    | 11   | 15   | 18   | 28   | 26   | 22   | 14   | 3    | -     | 14.23 | -    | 25   | 20   | 17   | -     | 20.11 | -    | 8    | 1    | -    | -    | -    | -    | -    | -    | - |
| Melrose, . . . . .        | 152   | 72  | 80  | -    | 12   | 25   | 7    | 1    | 2    | 1    | 6    | 2    | 1    | 16   | 13   | 9    | 15   | 19   | 21   | 14   | -    | 12.70 | -     | 25   | 20   | 17   | -    | 20.11 | -     | 8    | 1    | -    | -    | -    | -    | -    | -    | -    |   |
| Methuen, . . . . .        | 101   | 40  | 61  | -    | 4    | 24   | 3    | 3    | 1    | 1    | -    | 3    | 1    | 10   | 5    | 4    | 9    | 13   | 11   | 14   | -    | 17.75 | -     | 25   | 20   | 17   | -    | 20.11 | -     | 8    | 1    | -    | -    | -    | -    | -    | -    | -    |   |

\* One hundred and twenty-three deaths, of fishermen lost at sea, are not included in this total of 423.

† Two hundred and sixty-seven between the ages of one and five years.

‡ Eighty eight between the ages of ten and twenty years.



TABLE II. — Concluded.

|                               | Total Deaths. | Males. | Females. | Sex Unknown. | Still-births. | Deaths Under 1. | 1-9. | 10-19. | 20-29. | 30-39. | 40-49. | 50-59. | 60-69. | 70-79. | Over 80. | Age Unknown. | Rate per 1,000. |
|-------------------------------|---------------|--------|----------|--------------|---------------|-----------------|------|--------|--------|--------|--------|--------|--------|--------|----------|--------------|-----------------|
| Middleborough, . . . . .      | 100           | 43     | 57       | -            | 1             | 11              | 2    | 1      | 3      | 7      | 5      | 7      | 13     | 18     | 15       | -            | 14.95           |
| Millford, . . . . .           | 168           | 88     | 77       | 3            | 2             | 19              | 5    | 2      | 3      | 24     | 9      | 9      | 17     | 24     | 23       | 3            | 18.76           |
| Millbury, . . . . .           | 89            | 46     | 43       | -            | -             | 25              | 4    | -      | 1      | 9      | 5      | 4      | 4      | 8      | 11       | 7            | 17.04           |
| Milton, . . . . .             | 67            | 41     | 26       | -            | 6             | 8               | 4    | 3      | 2      | 7      | 4      | 2      | 6      | 9      | 13       | 6            | 12.14           |
| Natick, . . . . .             | 135           | 68     | 67       | -            | 4             | 11              | 6    | 4      | 5      | 17     | 9      | 13     | 9      | 18     | 28       | 12           | 15.08           |
| NEW BEDFORD, . . . . .        | 1,065         | 528    | 527      | -            | 60            | 330             | 55   | 35     | 32     | 68     | 65     | 59     | 98     | 103    | 85       | 61           | 19.10           |
| NEWBURYPORT, . . . . .        | 274           | 136    | 138      | -            | 12            | 41              | 4    | 5      | 7      | 30     | 13     | 20     | 25     | 44     | 43       | 31           | 18.83           |
| NEWTON, . . . . .             | 448           | 211    | 237      | -            | 29            | 93              | 25   | 17     | 17     | 23     | 34     | 35     | 31     | 48     | 57       | 43           | 16.24           |
| NORTH ADAMS, . . . . .        | 338           | 166    | 172      | -            | 19            | 84              | 11   | 8      | 6      | 42     | 24     | 25     | 24     | 24     | 28       | 19           | 17.06           |
| NORTHAMPTON, . . . . .        | 253           | 122    | 131      | -            | 11            | 60              | 8    | 4      | 0      | 23     | 21     | 28     | 25     | 31     | 36       | 10           | 15.11           |
| North Attleborough, . . . . . | 86            | 45     | 41       | -            | 5             | 13              | 1    | -      | -      | 10     | 11     | 7      | 11     | 11     | 10       | 6            | 13.06           |
| Northbridge, . . . . .        | 80            | 46     | 34       | -            | 2             | 22              | 2    | 2      | 2      | 5      | 8      | 3      | 7      | 6      | 12       | 3            | 15.13           |
| Orange, . . . . .             | 71            | 28     | 42       | 1            | 3             | 10              | 4    | 2      | -      | 3      | 5      | 8      | 3      | 5      | 12       | 13           | 13.24           |
| Palmer, . . . . .             | 150           | 83     | 72       | 4            | 8             | 34              | 10   | 13     | 12     | 9      | 7      | 5      | 8      | 14     | 16       | 8            | 23.13           |
| Peabody, . . . . .            | 217           | 98     | 119      | -            | 2             | 28              | 11   | 4      | 3      | 22     | 18     | 20     | 30     | 23     | 18       | 23           | 20.65           |
| PITTSFIELD, . . . . .         | 324           | 151    | 173      | -            | 30            | 61              | 5    | 6      | 1      | 35     | 36     | 30     | 29     | 42     | 41       | 17           | 15.83           |
| Plymouth, . . . . .           | 177           | 84     | 93       | -            | 3             | 16              | 2    | 4      | 1      | 10     | 9      | 13     | 20     | 29     | 33       | 33           | 22.24           |
| QUINCY, . . . . .             | 329           | 173    | 156      | -            | 34            | 69              | 18   | 7      | 5      | 26     | 34     | 26     | 22     | 27     | 29       | 26           | 16.88           |
| Revere, . . . . .             | 102           | 48     | 54       | -            | 12            | 18              | 4    | 2      | 1      | 8      | 9      | 10     | 12     | 11     | 7        | 2            | 13.74           |
| Rockland, . . . . .           | 84            | 39     | 45       | 2            | 1             | 5               | 3    | 4      | -      | 6      | 5      | 8      | 6      | 13     | 15       | 13           | 16.31           |



TABLE III.

Deaths by Months in Each City and Town having a Population of More than 5,000 by Census of 1895.

|                                    | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Unknown. |
|------------------------------------|----------|-----------|--------|--------|------|-------|-------|---------|------------|----------|-----------|-----------|----------|
| Adams, . . . . .                   | 7        | 10        | 11     | 6      | 6    | 5     | 7     | 24      | 18         | 17       | 11        | 7         | -        |
| Amesbury, . . . . .                | 18       | 21        | 17     | 12     | 14   | 13    | 14    | 16      | 9          | 15       | 13        | 14        | -        |
| Andover, . . . . .                 | 13       | 7         | 16     | 12     | 9    | 7     | 7     | 10      | 8          | 8        | 7         | 9         | -        |
| Arlington, . . . . .               | 5        | 7         | 11     | 9      | 11   | 6     | 9     | 12      | 8          | 7        | 8         | 9         | -        |
| Athol, . . . . .                   | 3        | 9         | 16     | 14     | 6    | 3     | -     | 14      | 6          | 5        | 9         | 7         | -        |
| Attleborough, . . . . .            | 11       | 8         | 17     | 10     | 11   | 5     | 7     | 16      | 13         | 14       | 6         | 9         | -        |
| Beverly, . . . . .                 | 16       | 17        | 17     | 10     | 16   | 14    | 9     | 28      | 15         | 16       | 17        | 15        | 1        |
| Blackstone, . . . . .              | 16       | 17        | 18     | 13     | 9    | 8     | 14    | 12      | 9          | 9        | 6         | 9         | -        |
| Boston, . . . . .                  | 960      | 1,028     | 1,007  | 900    | 891  | 783   | 918   | 1,131   | 978        | 946      | 858       | 929       | -        |
| Braintree, . . . . .               | 10       | 9         | 11     | 9      | 6    | 7     | 1     | 4       | 8          | 8        | 3         | 6         | -        |
| Brookton, . . . . .                | 46       | 46        | 56     | 55     | 29   | 28    | 23    | 47      | 33         | 33       | 33        | 36        | 1        |
| Brookline, . . . . .               | 23       | 26        | 20     | 23     | 16   | 10    | 10    | 20      | 28         | 24       | 26        | 19        | -        |
| Cambridge, . . . . .               | 127      | 117       | 127    | 133    | 107  | 104   | 127   | 161     | 131        | 134      | 120       | 112       | -        |
| Chelsea, . . . . .                 | 53       | 62        | 43     | 62     | 49   | 45    | 47    | 76      | 54         | 46       | 62        | 57        | -        |
| Chicopee, . . . . .                | 24       | 29        | 31     | 23     | 23   | 24    | 53    | 41      | 33         | 28       | 35        | 25        | -        |
| Clinton, . . . . .                 | 19       | 21        | 16     | 13     | 11   | 7     | 11    | 16      | 23         | 12       | 17        | 11        | -        |
| Concord, . . . . .                 | 6        | 7         | 7      | 6      | 10   | 2     | 3     | 8       | 6          | 4        | 6         | 6         | -        |
| Danvers, . . . . .                 | 7        | 13        | 9      | 9      | 8    | 6     | 8     | 10      | 6          | 10       | 14        | 9         | -        |
| Denver Lunatic Hospital, . . . . . | 9        | 7         | 8      | 7      | 12   | 11    | 7     | 13      | 12         | 12       | 9         | 11        | -        |

|                          |     |     |     |     |     |     |     |     |     |     |     |     |
|--------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| EVERETT, . . . . .       | 24  | 29  | 31  | 28  | 13  | 19  | 18  | 34  | 27  | 18  | 23  | 12  |
| FALL RIVER, . . . . .    | 128 | 149 | 185 | 149 | 116 | 124 | 297 | 203 | 187 | 148 | 124 | 133 |
| FITCHBURG, . . . . .     | 33  | 32  | 39  | 29  | 37  | 18  | 25  | 57  | 42  | 40  | 26  | 25  |
| FRAMINGHAM, . . . . .    | 15  | 14  | 15  | 8   | 14  | 14  | 8   | 11  | 17  | 11  | 13  | 8   |
| FRANKLIN, . . . . .      | 7   | 4   | 7   | 5   | 14  | 5   | 7   | 6   | 7   | 11  | 10  | 3   |
| GARDNER, . . . . .       | 23  | 16  | 24  | 18  | 13  | 9   | 8   | 13  | 16  | 14  | 8   | 15  |
| GLOUCESTER, . . . . .    | 36  | 29  | 52  | 33  | 31  | 22  | 38  | 52  | 36  | 28  | 40  | 25  |
| GREENFIELD, . . . . .    | 7   | 10  | 6   | 12  | 6   | 7   | 5   | 10  | 7   | 8   | 6   | 9   |
| HAVERHILL, . . . . .     | 25  | 58  | 53  | 57  | 36  | 37  | 45  | 47  | 28  | 38  | 25  | 52  |
| HUDSON, . . . . .        | 4   | 6   | 9   | 5   | 8   | 6   | 6   | 10  | 8   | 5   | 8   | 7   |
| HYDE PARK, . . . . .     | 15  | 23  | 18  | 16  | 16  | 7   | 20  | 25  | 24  | 10  | 15  | 14  |
| LAWRENCE, . . . . .      | 75  | 97  | 93  | 75  | 73  | 87  | 118 | 103 | 101 | 80  | 66  | 74  |
| LEOMINSTER, . . . . .    | 10  | 15  | 14  | 10  | 14  | 6   | 9   | 14  | 12  | 12  | 15  | 7   |
| LOWELL, . . . . .        | 137 | 174 | 168 | 162 | 107 | 135 | 198 | 176 | 162 | 156 | 136 | 146 |
| LYNN, . . . . .          | 72  | 117 | 113 | 84  | 82  | 68  | 84  | 104 | 99  | 91  | 84  | 88  |
| MALDEN, . . . . .        | 36  | 48  | 56  | 46  | 39  | 35  | 32  | 52  | 37  | 47  | 30  | 40  |
| MARLBOROUGH, . . . . .   | 10  | 9   | 13  | 13  | 10  | 12  | 14  | 18  | 18  | 11  | 7   | 17  |
| MARLBOROUGH, . . . . .   | 18  | 27  | 20  | 27  | 24  | 10  | 19  | 23  | 19  | 19  | 20  | 27  |
| MEDFORD, . . . . .       | 14  | 24  | 20  | 15  | 16  | 15  | 11  | 23  | 21  | 20  | 14  | 13  |
| MELROSE, . . . . .       | 7   | 20  | 9   | 22  | 10  | 14  | 11  | 16  | 11  | 15  | 9   | 8   |
| METHUEN, . . . . .       | 10  | 16  | 12  | 6   | 8   | 8   | 6   | 10  | 10  | 4   | 7   | 4   |
| MIDDLEBOROUGH, . . . . . | 9   | 14  | 12  | 4   | 8   | 7   | 3   | 8   | 6   | 10  | 8   | 12  |
| MILFORD, . . . . .       | 20  | 19  | 16  | 14  | 14  | 13  | 8   | 11  | 16  | 12  | 17  | 8   |
| MILBURY, . . . . .       | 6   | 11  | 6   | 8   | 9   | 3   | 9   | 9   | 12  | 4   | 5   | 7   |

TABLE III. — Concluded.

|                               | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Unknown. |
|-------------------------------|----------|-----------|--------|--------|------|-------|-------|---------|------------|----------|-----------|-----------|----------|
| Milton, . . . . .             | 7        | 7         | 9      | 6      | 1    | 2     | 5     | 7       | 7          | 7        | 5         | 4         | -        |
| Natick, . . . . .             | 18       | 14        | 16     | 11     | 8    | 9     | 10    | 11      | 8          | 12       | 9         | 9         | -        |
| NEW BEDFORD, . . . . .        | 80       | 90        | 117    | 68     | 81   | 73    | 85    | 126     | 74         | 71       | 100       | 80        | -        |
| NEWBURYPORT, . . . . .        | 23       | 26        | 26     | 25     | 22   | 10    | 27    | 27      | 26         | 25       | 19        | 19        | -        |
| NEWTON, . . . . .             | 35       | 44        | 29     | 35     | 39   | 30    | 42    | 42      | 43         | 43       | 36        | 30        | -        |
| NORTH ADAMS, . . . . .        | 22       | 24        | 32     | 18     | 28   | 23    | 35    | 35      | 38         | 36       | 27        | 20        | -        |
| NORTHAMPTON, . . . . .        | 19       | 25        | 22     | 12     | 24   | 16    | 15    | 43      | 20         | 24       | 14        | 19        | -        |
| North Attleborough, . . . . . | 6        | 5         | 12     | 7      | 9    | 10    | 6     | 8       | 7          | 6        | 2         | 8         | -        |
| Northbridge, . . . . .        | 12       | 5         | 5      | 4      | 3    | 6     | 5     | 8       | 6          | 5        | 6         | 15        | -        |
| Orange, . . . . .             | 8        | 5         | 10     | 10     | 3    | 5     | 4     | 7       | 6          | 3        | 6         | 4         | -        |
| Palmer, . . . . .             | 10       | 17        | 23     | 11     | 16   | 12    | 12    | 19      | 5          | 6        | 12        | 9         | 5        |
| Peabody, . . . . .            | 14       | 18        | 23     | 24     | 23   | 12    | 13    | 23      | 14         | 14       | 16        | 19        | -        |
| PITTSFIELD, . . . . .         | 22       | 44        | 28     | 29     | 23   | 23    | 24    | 33      | 32         | 19       | 25        | 22        | -        |
| Plymouth, . . . . .           | 12       | 18        | 20     | 14     | 14   | 19    | 10    | 15      | 16         | 16       | 11        | 12        | -        |
| QUINCY, . . . . .             | 35       | 22        | 29     | 26     | 31   | 23    | 28    | 34      | 26         | 24       | 31        | 20        | -        |
| Revere, . . . . .             | 4        | 6         | 8      | 6      | 9    | 8     | 12    | 14      | 11         | 7        | 9         | 8         | -        |
| Rockland, . . . . .           | 6        | 8         | 10     | 10     | 9    | 6     | 3     | 4       | 11         | 5        | 4         | 8         | -        |
| Rockport, . . . . .           | 11       | 11        | 14     | 12     | 6    | 4     | 7     | 12      | 15         | 13       | 3         | 4         | -        |
| SALEM, . . . . .              | 52       | 65        | 60     | 46     | 52   | 44    | 59    | 94      | 50         | 53       | 54        | 58        | -        |
| SOMERVILLE, . . . . .         | 84       | 97        | 77     | 73     | 70   | 47    | 55    | 85      | 58         | 60       | 62        | 70        | -        |
| Southbridge, . . . . .        | 12       | 16        | 16     | 16     | 14   | 18    | 9     | 21      | 19         | 16       | 11        | 14        | -        |

|               |   |   |   |   |   |       |       |       |       |       |       |       |       |       |       |       |       |    |
|---------------|---|---|---|---|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----|
| Stoneham, .   | . | . | . | . | . | 6     | 13    | 11    | 7     | 6     | 6     | 12    | 17    | 7     | 10    | 7     | 9     | -  |
| Stoughton, .  | . | . | . | . | . | 9     | 13    | 16    | 11    | 13    | 6     | 11    | 12    | 12    | 6     | 6     | 4     | -  |
| TAUNTON, .    | . | . | . | . | . | 44    | 47    | 58    | 30    | 35    | 43    | 49    | 49    | 45    | 45    | 34    | 35    | -  |
| Wakefield, .  | . | . | . | . | . | 12    | 20    | 16    | 16    | 8     | 9     | 12    | 11    | 12    | 8     | 13    | 16    | -  |
| WALTHAM, .    | . | . | . | . | . | 24    | 30    | 26    | 20    | 28    | 22    | 23    | 42    | 27    | 31    | 31    | 19    | -  |
| Ware, .       | . | . | . | . | . | 16    | 13    | 9     | 9     | 12    | 3     | 10    | 16    | 19    | 13    | 10    | 19    | -  |
| Watertown, .  | . | . | . | . | . | 11    | 9     | 8     | 12    | 8     | 10    | 8     | 11    | 9     | 6     | 12    | 11    | -  |
| Webster, .    | . | . | . | . | . | 14    | 15    | 7     | 6     | 4     | 11    | 2     | 13    | 14    | 10    | 10    | 7     | -  |
| Westfield, .  | . | . | . | . | . | 11    | 21    | 25    | 14    | 11    | 11    | 20    | 21    | 8     | 11    | 13    | 16    | -  |
| Weymouth, .   | . | . | . | . | . | 20    | 20    | 19    | 20    | 17    | 13    | 20    | 27    | 13    | 15    | 10    | 11    | -  |
| Whitman, .    | . | . | . | . | . | 11    | 7     | 9     | 4     | 6     | 4     | 10    | 8     | 6     | 16    | 4     | 7     | -  |
| Winchester, . | . | . | . | . | . | 9     | 8     | 12    | 9     | 9     | 6     | 3     | 7     | 10    | 3     | 4     | 11    | -  |
| Woburn, .     | . | . | . | . | . | 16    | 23    | 24    | 23    | 25    | 16    | 25    | 42    | 40    | 17    | 30    | 19    | -  |
| WORCESTER, .  | . | . | . | . | . | 155   | 153   | 200   | 117   | 142   | 107   | 147   | 163   | 153   | 156   | 134   | 145   | -  |
| Total, .      | . | . | . | . | . | 3,092 | 3,503 | 3,556 | 3,166 | 2,885 | 2,515 | 3,153 | 3,919 | 3,237 | 2,944 | 2,843 | 2,925 | 10 |

TABLE IV.  
Deaths from Specified Causes in Cities and Towns having More than 5,000 Inhabitants in Each, by Census of 1895.

|                               | Consumption. | Measles. | Scarlet Fever. | Diphtheria and Croup. | Whooping-cough. | Typhoid Fever. | Cerebro-spinal Meningitis. | Erysipelas. | Puerperal Fever. | Influenza. | Malarial Fever. | Cholera Infantum. | Dysentery. | Diarrhoea and Cholera Morbus. | Pneumonia. | Bronchitis. | Diseases of the Heart. | Diseases of the Brain and Spinal Cord. | Kidneys. | Cancer. | Suicide. | Accident. | Unknown or Ill-defined Causes. | All Other Causes. |
|-------------------------------|--------------|----------|----------------|-----------------------|-----------------|----------------|----------------------------|-------------|------------------|------------|-----------------|-------------------|------------|-------------------------------|------------|-------------|------------------------|----------------------------------------|----------|---------|----------|-----------|--------------------------------|-------------------|
| Adams, . . . . .              | 18           | -        | -              | 6                     | -               | 10             | 5                          | -           | -                | -          | -               | 13                | -          | -                             | 9          | 4           | 9                      | 5                                      | 8        | 7       | 1        | 3         | -                              | 30                |
| Amesbury, . . . . .           | 22           | 3        | 2              | 8                     | 2               | 1              | 9                          | 1           | 1                | -          | -               | 4                 | -          | 2                             | 25         | 4           | 15                     | 23                                     | 6        | 15      | 1        | 4         | 2                              | 16                |
| Andover, . . . . .            | 11           | 1        | -              | -                     | -               | -              | -                          | -           | -                | -          | -               | 1                 | -          | -                             | 7          | 6           | 14                     | 11                                     | 1        | 3       | -        | 3         | -                              | 45                |
| Arlington, . . . . .          | 12           | -        | -              | 5                     | -               | 5              | -                          | -           | 1                | 1          | -               | 1                 | 1          | 3                             | 8          | 4           | 8                      | 19                                     | 4        | 3       | 1        | 5         | 2                              | 15                |
| Athol, . . . . .              | 8            | -        | 1              | -                     | 1               | 3              | 4                          | -           | -                | -          | 1               | 3                 | -          | -                             | 6          | -           | 14                     | 7                                      | 4        | 3       | 1        | 3         | 1                              | 32                |
| Attleborough, . . . . .       | 15           | 3        | 12             | 6                     | -               | 7              | 1                          | 1           | -                | -          | 1               | 4                 | -          | -                             | 11         | -           | 6                      | 23                                     | 12       | 4       | 1        | 3         | 17                             | -                 |
| Beverly, . . . . .            | 13           | -        | -              | 16                    | -               | 3              | 4                          | -           | -                | -          | -               | 2                 | 2          | 1                             | 24         | 3           | 13                     | -                                      | 14       | 8       | -        | 4         | -                              | 84                |
| Blackstone, . . . . .         | 22           | -        | -              | 13                    | 2               | 2              | 4                          | 1           | -                | 2          | 1               | 9                 | -          | 2                             | 8          | 1           | 8                      | 13                                     | 8        | 1       | 1        | 4         | -                              | 32                |
| Boston, . . . . .             | 1,349        | 19       | 114            | 654                   | 47              | 163            | 15                         | 34          | 14               | 69         | 6               | 500               | 43         | 84                            | 1,263      | 439         | 870                    | 551                                    | 377      | -       | 77       | 444       | 62                             | 4,077             |
| Braintree, . . . . .          | 5            | -        | -              | 5                     | -               | -              | 5                          | 1           | -                | 1          | 1               | 3                 | -          | -                             | 16         | 2           | 6                      | 10                                     | 1        | 4       | -        | 3         | -                              | 19                |
| Brockton, . . . . .           | 72           | 1        | 5              | 13                    | 4               | 10             | 6                          | 1           | 3                | -          | -               | 20                | 3          | 4                             | 59         | 11          | 23                     | 20                                     | 16       | 9       | 6        | 2         | -                              | 198               |
| Brookline, . . . . .          | 23           | -        | 1              | 15                    | -               | 3              | -                          | 1           | -                | -          | -               | 10                | -          | -                             | 16         | 10          | 19                     | -                                      | 7        | 18      | 1        | 1         | -                              | 120               |
| CAMBRIDGE, . . . . .          | 181          | 3        | 17             | 106                   | 11              | 12             | 3                          | 5           | 1                | 20         | 2               | 69                | 3          | 66                            | 122        | 41          | 113                    | 149                                    | 56       | 63      | 4        | 47        | 121                            | 234               |
| CHELSEA, . . . . .            | 99           | -        | 10             | 46                    | 3               | 2              | 35                         | -           | 1                | 5          | -               | 19                | 2          | 5                             | 47         | 24          | 72                     | 21                                     | 19       | 25      | 4        | 14        | -                              | 203               |
| CHICOPEE, . . . . .           | 30           | 1        | 5              | 7                     | 3               | 4              | 1                          | -           | -                | 7          | 1               | 52                | 2          | 2                             | 30         | 10          | 27                     | 18                                     | 13       | 7       | 2        | 7         | -                              | 140               |
| Clinton, . . . . .            | 29           | 4        | -              | 3                     | 4               | 6              | 9                          | -           | 1                | 3          | -               | 7                 | 5          | 3                             | 15         | 2           | 12                     | 16                                     | 6        | 5       | 3        | 3         | -                              | 40                |
| Concord, . . . . .            | 2            | -        | 1              | -                     | -               | -              | -                          | 1           | 1                | 2          | -               | 1                 | 1          | -                             | 7          | 3           | 9                      | 7                                      | 1        | 2       | -        | 6         | -                              | 18                |
| DANVERS, . . . . .            | -            | -        | 1              | 2                     | -               | 1              | -                          | -           | -                | 1          | -               | 2                 | -          | 1                             | 10         | 6           | 7                      | 43                                     | 6        | 8       | 1        | 4         | -                              | 12                |
| Danvers Lying-in Hospital, 18 | -            | -        | -              | -                     | -               | -              | -                          | 6           | -                | 4          | -               | -                 | 5          | 5                             | 15         | 1           | 7                      | 26                                     | 4        | 2       | 1        | -         | -                              | 10                |

|                          |     |   |    |    |    |    |    |   |   |    |    |     |    |    |     |    |     |     |    |    |   |    |    |     |
|--------------------------|-----|---|----|----|----|----|----|---|---|----|----|-----|----|----|-----|----|-----|-----|----|----|---|----|----|-----|
| EVERETT, . . . . .       | 23  | - | 8  | 13 | -  | 5  | -  | - | - | 7  | -  | 8   | -  | 10 | 23  | 7  | 19  | 2   | 8  | 14 | 2 | 5  | -  | 112 |
| FALL RIVER, . . . . .    | 154 | 1 | 29 | 27 | 6  | 30 | 6  | 4 | - | 13 | 3  | 231 | 4  | 24 | 132 | 94 | 88  | 265 | 70 | 23 | - | 50 | 20 | 609 |
| FITCHBURG, . . . . .     | 42  | - | 1  | 10 | 2  | 8  | -  | 3 | 2 | 4  | -  | 37  | 1  | 4  | 25  | 16 | 29  | 49  | 12 | 8  | 3 | 8  | -  | 139 |
| FRAMINGHAM, . . . . .    | 16  | 1 | -  | 2  | 1  | 2  | 4  | - | - | -  | -  | 2   | -  | -  | 16  | 5  | 22  | 6   | 4  | 9  | - | 6  | -  | 53  |
| FRANKLIN, . . . . .      | 4   | - | -  | 5  | -  | 1  | 4  | - | 1 | 1  | -  | 8   | -  | 1  | 5   | 6  | 15  | 7   | 6  | 4  | - | 1  | -  | 22  |
| GARDNER, . . . . .       | 24  | 2 | 2  | -  | 2  | 3  | 2  | 1 | 2 | 9  | -  | 11  | -  | 6  | 13  | 5  | 7   | 7   | 6  | 3  | 2 | 5  | 7  | 58  |
| GLOUCESTER, . . . . .    | 54  | - | 6  | 25 | 1  | 4  | 21 | - | 1 | -  | -  | 19  | 1  | 3  | 43  | 4  | 27  | 14  | 15 | 10 | 1 | 18 | -  | 155 |
| GREENFIELD, . . . . .    | 10  | - | 1  | -  | 2  | 3  | 2  | - | - | 1  | -  | 1   | -  | -  | 7   | -  | 9   | 2   | 4  | 6  | 1 | 4  | -  | 40  |
| HAVERHILL, . . . . .     | 67  | 5 | 6  | 11 | 12 | 8  | 3  | 3 | 6 | 16 | -  | 17  | -  | 3  | 45  | 9  | 49  | 24  | 21 | 13 | 3 | 16 | 2  | 182 |
| HUDSON, . . . . .        | 8   | - | -  | 5  | -  | 2  | 4  | - | - | 3  | -  | 2   | 2  | 2  | 4   | 2  | 12  | 2   | 3  | 3  | - | 3  | 1  | 24  |
| HYDE PARK, . . . . .     | 17  | - | 2  | 7  | 2  | 1  | 9  | - | - | 1  | -  | 8   | 1  | 1  | 8   | 3  | 15  | -   | 4  | 9  | 1 | 16 | -  | 98  |
| LAWRENCE, . . . . .      | 70  | 4 | 12 | 9  | 3  | 16 | 4  | 1 | 4 | -  | -  | 96  | 4  | 6  | 59  | 15 | 53  | 54  | 23 | 32 | 7 | 35 | 6  | 524 |
| LEOMINSTER, . . . . .    | 21  | - | -  | -  | -  | 1  | -  | - | - | 1  | -  | 7   | 1  | -  | 12  | 3  | 13  | 11  | 2  | 4  | 3 | 7  | -  | 52  |
| LOWELL, . . . . .        | 153 | 1 | 4  | 53 | 10 | 33 | 7  | 1 | 4 | 26 | 1  | 218 | 4  | 4  | 153 | 77 | 154 | 253 | 62 | 47 | 7 | 59 | 2  | 509 |
| LYNN, . . . . .          | 122 | - | 25 | 42 | 8  | 13 | 44 | 2 | 1 | 26 | -  | 33  | 2  | 12 | 85  | 33 | 89  | 7   | 33 | 35 | 5 | 19 | -  | 445 |
| MALDEN, . . . . .        | 70  | - | 11 | 20 | 1  | 7  | -  | 1 | 3 | 6  | 11 | 26  | 11 | 4  | 35  | 12 | 63  | 49  | 30 | 27 | 4 | 14 | 4  | 97  |
| MARBLEHEAD, . . . . .    | 9   | - | 1  | 13 | 2  | 4  | 4  | - | 1 | 3  | -  | 8   | 1  | 8  | 9   | 4  | 34  | 27  | 9  | 8  | 1 | 7  | 4  | -   |
| MARLBOROUGH, . . . . .   | 44  | 1 | 1  | 2  | 4  | 2  | 4  | 2 | - | 1  | -  | 11  | 4  | 3  | 23  | 5  | 32  | 17  | 12 | 2  | 1 | 4  | 12 | 76  |
| MEDFORD, . . . . .       | 16  | - | 1  | 9  | -  | 3  | -  | - | - | -  | 1  | 8   | -  | 4  | 17  | 8  | 14  | -   | 11 | 16 | 5 | 4  | 1  | 88  |
| MELROSE, . . . . .       | 13  | - | 2  | 6  | -  | 4  | -  | 1 | 1 | -  | -  | 5   | 1  | 1  | 7   | 1  | 14  | 24  | 6  | 4  | - | 2  | -  | 60  |
| METHUEN, . . . . .       | 20  | 1 | 1  | 2  | -  | 1  | 4  | 1 | - | 2  | -  | 6   | -  | 2  | 5   | 2  | 9   | -   | 2  | 1  | 1 | 1  | -  | 41  |
| MIDDLEBOROUGH, . . . . . | 11  | - | 1  | 1  | -  | 2  | 1  | - | - | 3  | -  | -   | 1  | -  | 6   | -  | 12  | 3   | -  | 2  | 3 | 8  | -  | 52  |
| MILFORD, . . . . .       | 22  | 1 | -  | 6  | 1  | 2  | 2  | 3 | 2 | 1  | 3  | 7   | 2  | 2  | 29  | 6  | 14  | 19  | 14 | 1  | - | 3  | -  | 26  |
| MILBURY, . . . . .       | 14  | - | -  | 2  | -  | -  | -  | - | - | -  | -  | 7   | -  | -  | 6   | 8  | 7   | 1   | 4  | -  | - | 3  | -  | 37  |



TABLE IV. — Concluded.

|                               | Consumption. | Measles. | Scarlet Fever. | Diphtheria and Croup. | Whooping-cough. | Typhoid Fever. | Cerebro-spinal Meningitis. | Erysipelas. | Fuerepal Fever. | Influenza. | Malarial Fever. | Cholera Infantum. | Dysentery. | Diarrhea and Cholera Morbus. | Pneumonia. | Bronchitis. | Diseases of the Heart. | Diseases of the Brain and Spinal Cord. | Diseases of the Kidneys. | Cancer. | Suicide. | Accident. | Unknown or Ill-defined Causes. | All Other Causes. |
|-------------------------------|--------------|----------|----------------|-----------------------|-----------------|----------------|----------------------------|-------------|-----------------|------------|-----------------|-------------------|------------|------------------------------|------------|-------------|------------------------|----------------------------------------|--------------------------|---------|----------|-----------|--------------------------------|-------------------|
| Milton, . . . . .             | 5            | -        | 1              | 3                     | -               | 2              | 2                          | -           | -               | 1          | -               | 1                 | -          | 1                            | 2          | 3           | 6                      | -                                      | 2                        | 2       | 1        | -         | -                              | 34                |
| Natick, . . . . .             | 11           | 1        | 2              | 2                     | -               | 2              | 1                          | 1           | -               | 1          | -               | 2                 | -          | -                            | 12         | 4           | 16                     | 1                                      | 7                        | 6       | 1        | 1         | -                              | 63                |
| NEW BEDFORD, . . . . .        | 97           | 1        | 5              | 30                    | 4               | 9              | 4                          | 5           | -               | 4          | 1               | 66                | 4          | 6                            | 78         | 21          | 94                     | 10                                     | 49                       | 37      | -        | 2         | 11                             | 517               |
| NEWBURYPORT, . . . . .        | 28           | -        | 2              | 1                     | 1               | 8              | 1                          | -           | 1               | 6          | -               | 9                 | 1          | 1                            | 15         | 5           | 31                     | -                                      | 9                        | 13      | 1        | 8         | -                              | 133               |
| NEWTON, . . . . .             | 44           | 1        | 1              | 21                    | -               | 3              | 2                          | -           | -               | 7          | 1               | 16                | 3          | 2                            | 42         | 15          | 40                     | 59                                     | 12                       | 21      | 4        | 8         | -                              | 146               |
| NORTH ADAMS, . . . . .        | 31           | -        | 1              | 15                    | -               | -              | -                          | -           | -               | 4          | -               | 30                | 3          | 5                            | 34         | 3           | 14                     | 40                                     | 8                        | 13      | 2        | 16        | -                              | 119               |
| NORTHAMPTON, . . . . .        | 36           | -        | -              | 3                     | 5               | 3              | -                          | -           | 1               | 5          | -               | 11                | 4          | 3                            | 14         | 10          | 21                     | 13                                     | 8                        | 6       | 2        | 6         | -                              | 101               |
| North Attleborough, . . . . . | 16           | -        | -              | 1                     | -               | 1              | -                          | -           | -               | 4          | -               | 2                 | -          | -                            | 2          | 4           | 7                      | 12                                     | 6                        | 4       | 1        | 3         | -                              | 23                |
| Northbridge, . . . . .        | 4            | -        | 3              | -                     | -               | 2              | -                          | -           | -               | -          | -               | 4                 | -          | 1                            | 10         | -           | 3                      | 6                                      | 6                        | 1       | -        | 7         | 1                              | 32                |
| Orange, . . . . .             | 10           | -        | -              | 1                     | 3               | -              | 2                          | -           | -               | 1          | 1               | -                 | 1          | -                            | -          | 4           | 6                      | -                                      | -                        | 2       | -        | 3         | 3                              | 34                |
| Palmer, . . . . .             | 5            | -        | 25             | 19                    | -               | 2              | 2                          | -           | -               | 3          | -               | 12                | -          | -                            | 19         | 3           | 9                      | 12                                     | 6                        | 6       | 2        | 2         | -                              | 32                |
| Peabody, . . . . .            | 22           | -        | 1              | 3                     | -               | 5              | 6                          | 1           | 1               | 4          | -               | 8                 | -          | 1                            | 9          | 3           | 19                     | 6                                      | 14                       | 8       | -        | -         | -                              | 106               |
| PITTSFIELD, . . . . .         | 46           | -        | 1              | -                     | -               | 3              | -                          | 1           | -               | 1          | -               | 21                | -          | 8                            | 22         | 12          | 37                     | 34                                     | 2                        | 7       | 1        | 17        | -                              | 110               |
| Plymouth, . . . . .           | 13           | -        | 2              | -                     | -               | -              | -                          | -           | 2               | 2          | 1               | 2                 | -          | -                            | 8          | 7           | 12                     | 2                                      | 5                        | 8       | 3        | 2         | 23                             | 87                |
| QUINCY, . . . . .             | 56           | -        | 4              | 17                    | 2               | 7              | 16                         | -           | 1               | 1          | -               | 18                | -          | 1                            | 20         | 8           | 30                     | 25                                     | 9                        | 15      | 2        | 11        | 1                              | 85                |
| Revere, . . . . .             | 8            | -        | -              | 5                     | -               | 2              | 3                          | -           | -               | 1          | -               | 4                 | -          | 1                            | 5          | 7           | 6                      | 5                                      | 2                        | -       | -        | 1         | 5                              | 47                |
| Rockland, . . . . .           | 13           | -        | 5              | -                     | 1               | 2              | -                          | -           | -               | 3          | -               | 3                 | -          | -                            | 7          | 3           | 10                     | 7                                      | 10                       | 4       | -        | 2         | 2                              | 12                |
| Rockport, . . . . .           | 6            | -        | -              | 1                     | 1               | 3              | -                          | -           | 1               | -          | -               | -                 | 2          | 1                            | 7          | 4           | 10                     | 8                                      | -                        | 1       | 1        | 4         | -                              | 61                |
| SALEM, . . . . .              | 51           | 1        | 8              | 12                    | 2               | 7              | 2                          | 1           | -               | 3          | -               | 44                | 7          | 16                           | 51         | 24          | 65                     | 6                                      | 30                       | 17      | 4        | 14        | -                              | 321               |
| SEABOARD, . . . . .           | 91           | 1        | 17             | 49                    | 3               | 10             | 45                         | 2           | -               | -          | -               | 32                | 3          | 7                            | 99         | 21          | 60                     | 17                                     | 21                       | 27      | 6        | 18        | -                              | 302               |

[illegible]

|                        | Homicide. | Glanders.                |
|------------------------|-----------|--------------------------|
| Boston, . . . . .      | 22        | . . . . . 1              |
| Lawrence, . . . . .    | 2         | . . . . . 1              |
| Natick, . . . . .      | 1         | . . . . . —              |
| Newburyport, . . . . . | 2         | . . . . . 2              |
| Northampton, . . . . . | 1         | . . . . .                |
| Pittsfield, . . . . .  | 1         | . . . . .                |
| Springfield, . . . . . | 1         | . . . . .                |
| Worcester, . . . . .   | 1         | . . . . .                |
| Total, . . . . .       | 31        | . . . . . 1              |
| Cambridge,             | .         | . . . . . Actinomycosis. |

### Actinomycosis.

TABLE V.

| CAUSES OF DEATH.           | Deaths. | Mortality<br>per 10,000<br>of the<br>Population,<br>1895. | CAUSES OF DEATH.                          | Deaths. | Mortality<br>per 10,000<br>of the<br>Population,<br>1895. |
|----------------------------|---------|-----------------------------------------------------------|-------------------------------------------|---------|-----------------------------------------------------------|
| Consumption, . . .         | 4,178   | 21.20                                                     | Dysentery, . . . .                        | 157     | 0.80                                                      |
| Measles, . . . .           | 88      | 0.40                                                      | Diarrhœa and cholera mor-<br>bus.         | 411     | 2.08                                                      |
| Scarlet fever, . . .       | 410     | 2.10                                                      | Pneumonia, . . . .                        | 3,453   | 17.50                                                     |
| Diphtheria and croup, .    | 1,553   | 7.80                                                      | Bronchitis, . . . .                       | 1,214   | 6.15                                                      |
| Whooping-cough, . .        | 205     | 1.04                                                      | Diseases of the heart, .                  | 3,044   | 15.40                                                     |
| Typhoid fever, . . .       | 525     | 2.60                                                      | Diseases of the brain and<br>spinal cord. | 2,624   | 13.30                                                     |
| Cerebro-spinal meningitis, | 357     | 1.80                                                      | Diseases of the kidneys, .                | 1,372   | 6.96                                                      |
| Erysipelas, . . . .        | 106     | 0.55                                                      | Cancer, . . . .                           | 881     | 4.47                                                      |
| Puerperal fever, . . .     | 81      | 0.41                                                      | Suicide, . . . .                          | 210     | 1.06                                                      |
| Influenza, . . . .         | 341     | 1.70                                                      | Accident, . . . .                         | 1,146   | 5.90                                                      |
| Malarial fever, . . .      | 52      | 0.26                                                      | Unknown or ill-defined<br>causes.         | 409     | 2.33                                                      |
| Cholera infantum, . .      | 2,106   | 10.70                                                     |                                           |         |                                                           |

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# HEALTH OF TOWNS.

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[751]



## HEALTH OF TOWNS.

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The following digest contains such extracts from the annual reports of the local boards of health of cities and towns as pertain to matters of sanitary importance in the different municipalities from whose reports they are quoted.

The most notable point observed in these reports is the unanimity with which local boards have entered upon the work of controlling the spread and limiting the mortality from diphtheria by the introduction of the use of antitoxin. In nearly all the cities and large towns and in many of the smaller towns the use of this agent has become quite general, and the success attained by such use appears to have been uniformly good. It is to be hoped that, along with the gain derived from this additional aid to the sanitary authority, the usual and quite important measures of isolation, notification, disinfection and general municipal cleanliness will not be slackened in the least degree.

Attention is especially called to the statement in the extract from the report of the Concord board of health relative to the authority or jurisdiction of a local board of health over a public institution existing within the limits of the area over which the local board of health acts. There are at present many such institutions and establishments located in the different cities and towns, and their number is annually increasing. A full statement of the question involved has been published by the authorities of the State Reformatory at Concord.

### HEALTH OF TOWNS.

#### AMESBURY.

The election of the board of health was illegal. The duties of the board were devolved to the selectmen, and they availed themselves of a statutory provision and appointed an agent.

The vault and cesspool method of caring for the sewage has been in general use so long that some sections of the town are saturated with filth, that in some instances vault fluids have leaked through into adjacent houses.

A few cases of tuberculosis have been discovered in our town, and the animals quarantined and slaughtered by order of the State officers. Every dairyman should have his herd tested, for it will be only a few years when consumers of milk will demand a certified article.

Diphtheria has been unusually severe, there having been 24 cases, 9 of which were fatal. Up to October 18 there have been 8 cases, with 4 deaths; since the above date there have been 16 cases, with 3 deaths. In 12 of these 16 cases antitoxin was used, with only 2 deaths; in 4 of these 16 cases antitoxin was not used, and one died. In one of the fatal cases where antitoxin was used the case had advanced two weeks before the use of the drug, and the other case was advanced from Tuesday to Friday. It is necessary to use antitoxin early in the development of the disease, to get the best results. A supply of antitoxin is constantly kept on hand by this board, and in cases of poor families is furnished free of charge.

#### ANDOVER.

During the year twenty-six cases of nuisance have been investigated by the board. Advice in regard to the location of six cesspools has been given. Two examinations and certificates for plumbers have been received, and one permit granted to keep a boarding-house for infants.

The various slaughter houses and rendering establishments have been under the supervision of your Board, and have been visited frequently.

#### ARLINGTON.

Our town the past year has been remarkably free from the prevalence of epidemics of contagious or other diseases.

The board has given prompt attention to all calls for its services to abate nuisances and remedy sanitary defects.

In most cases parties interested have readily responded to requirements of the board, with results satisfactory to all concerned.

#### ATTLEBOROUGH.

The present board early in the year published a notice inviting all citizens who knew of any nuisance or any condition which they deemed a nuisance or a menace to the public health to notify the board in writing. Owing, doubtless, to this fact, it is safe to say that there have been more cases of this nature reported during the past year than in any preceding year in the history of the town. The board has made a special effort to remedy an evil which we believe has, in the past, been the cause of much infectious illness in our town.

Of the animals killed during the past year in town for beef purposes, twelve have been found to be afflicted with tuberculosis. Some of these animals, apparently healthy, have been used as milk producers. We wish it were possible to require every milk producer to have his herd examined before he is allowed to dispose of a single quart of milk.

#### AYER.

Four cases of typhoid fever were contracted out of town, three occurred in families using water from old wells, five were of unknown origin.

#### BELMONT.

The town has been remarkably free from contagious diseases during the last year. Only one death occurred during the year from contagious disease, that being from diphtheria.

The completion of the main line of the metropolitan sewer in the summer 1895 was a matter looked upon by the board of health as one of great importance toward promoting the good sanitary condition of the town. This completion necessitated the adoption of plumbing regulations, which were accordingly drawn up by the board, accepted by the town and incorporated as a part of its by-laws.

#### BILLERICA.

We have from time to time inspected wells, cesspools and vaults and made analyses of drinking water, both in the Centre and North villages, and have advised such cleansing and changes of construction as seemed to be demanded in the interest of health. We cannot too earnestly call attention to the importance of keeping the drinking water free from all pollution, by drainage, from cesspools or vaults.

#### BLACKSTONE.

During the year the board attended to all complaints made to them, and most cases with good results; but in a few cases the persons to whom instructions to abate nuisances were given did not promptly attend to them, either from neglect or for the purpose of making themselves thoroughly disagreeable. All cases have been properly examined, however, and such suggestions made as are likely to obviate future cause of complaint.



## BOSTON.

The total number of deaths for the year was 11,329, a decrease from the previous year of 191 deaths. The population, as estimated at the end of the year, is 501,083. The death rate for the year, as calculated on this population, is 22.60 per 1,000 inhabitants. This rate is less by .38 than that of the previous year, and the lowest since 1889.

There were 229 less deaths from diphtheria than in 1894, although the number of cases of diphtheria reported was largely increased on account of the larger number discovered among the pupils in the public schools by the medical inspectors of schools, and the bacteriological tests in the otherwise unrecognized cases. The ratio of deaths to the number of cases of diphtheria reported has been reduced by more than one-half.

Very complete tables are published, showing the mortality from infectious diseases in Boston in 1895, by months, sex, nativity, color and ages.

*Bacteriology.*

The bacteriological work in culture diagnosis of diphtheria, begun by the board of health in October, 1894, has been continued at the Harvard Medical School Laboratory under the charge of Prof. Harold C. Ernst.

*Medical Inspection of Schools and Supervision of Contagious Diseases.*

The inspection of schools, which was commenced in November, 1894, and described fully in our last annual report, has been followed through the year with excellent results. The schools have been visited daily, and all children who have complained of illness or appeared to the teachers to be ill have been examined by the visiting physician, who, in all cases, advises the teachers what to do with the pupil. This work has now been in progress for fourteen months, and it has demonstrated the fact that there are not only many cases of contagious diseases to be found in the schools, and which require early recognition and removal, but that there are large numbers of school children whose illness and whose disposition by the teacher require the decision of a competent physician.

For the fourteen months ending Dec. 31, 1895, 16,790 pupils were examined, 10,737 of whom were found to be ill; 6,053 were found not to be ill, and 2,041 of these were too ill to remain in school for the day.

Seventy-seven cases of diphtheria, 28 cases of scarlet fever, 116 of measles, 28 of chicken-pox, 69 of pediculosis, 47 of scabies, 47 of mumps, 33 of whooping-cough and 8 of congenital syphilis were found in children sitting in their seats spreading these diseases to other children. The remaining 10,372 sick children were suffering from a large variety of other diseases.

Commendable efforts were made by the board in the direction of a general improvement of the sanitary condition of the school-houses of Boston. In view of the fact that contagious diseases may easily be spread in the schools through the medium of infected books, pencils, sponges, slates, desks and other surfaces of the school-room, handled or used by the children, the following recommendation was made to the school committee in 1894 :—

*To the Honorable School Committee, City of Boston.*

GENTLEMEN :—The board of health begs respectfully to recommend that the desks, chairs, window-sills, wainscotings, doors, door-knobs and such other surfaces as are likely to be handled by the children within the school buildings be carefully rubbed with cloths or sponges, wet with a solution of corrosive sublimate (one part of corrosive sublimate to one thousand parts of water), as often as every Saturday during the school year; that the floors of the school-houses be well covered with sawdust thoroughly wet with the same disinfecting solution, at least once a week, and the sawdust swept up and burned; that the use of all slates, slate-pencils and sponges for slate use be discontinued, and that paper and lead-pencils be substituted.

The disinfection of books is scarcely practicable except by fire, and the board would recommend, whenever it is known that a book has been handled by a pupil who was, at the time, affected with a contagious disease, or the book is otherwise much soiled, it be immediately burned.

Very respectfully,

THE BOARD OF HEALTH,

By S. H. DURGIN, *Chairman.*

The following action was subsequently taken by the school committee :—

*Report of Committee on Hygiene and Physical Training.*

The committee on hygiene and physical training, to whom was referred—October 27—an order “that the committee on hygiene and physical training consider and report what action, if any, can be taken by this board to disinfect, or render aseptic, the school-books used in the schools,” report that careful consideration was given to the order, but no practical method could be found.

Up to this time nothing but fire is considered a sure disinfectant, therefore the books could be rendered aseptic only by destruction at stated intervals. As this committee do not feel at liberty to recommend this action, they have no suggestion to offer concerning the disinfection of books; however, that it will be entirely practicable to discontinue the use of slates and slate-pencils, and the necessary accompaniment, sponges. There are three good reasons why the use of slates and slate-pencils should be discontinued :—

*First*, a light gray mark upon a slightly darker gray surface is more or less distinct, and trying to the eyesight.

*Second*, the resistance of the hard pencil upon the hard slate is tiring to the muscles, and the resistance, to which the muscles are trained by the use of slates and slate-pencils, must be overcome when beginning to write with pencil or pen on paper.

*Third*, and last, but not least, the use of slates, slate-pencils and sponges is a very uncleanly custom, and leads to and establishes very uncleanly habits.

The committee also deprecate the custom of the daily distribution and regathering of lead-pencils, for the reasons which must be apparent to all after a moment's consideration. The pencil not infrequently finds a resting-place between the teeth and lips, and it is hardly to be supposed that the same pencil will be given to the same pupil the next day.

The committee, therefore, recommend the passage of the following orders:—

*Ordered*, That the use of slates and slate-pencils and sponges be discontinued, and that paper, lead-pencils and rubber erasers be supplied in their places.

*Ordered*, That lead-pencils and erasers be given to each pupil at the beginning of the term, to be retained by the pupil for his sole use during the school year.

JUNE 25, 1896.

*Ordered*, That the committee on accounts be requested to direct janitors to cover during the summer vacation all the floors of school-houses with sawdust wet with a solution of bichloride of mercury (one part of bichloride of mercury to three thousand parts of water), and sweep the sawdust before it becomes dry; also sponge off all chairs, desks, window-sills, wainscotings, doors and door-knobs with a solution of the same strength, and wipe off with a wet cloth before they become dry. All applications may be made with a sponge or cloth mounted upon a handle or stick, so that the hands need not be put into the solution.

### *Diphtheria.*

A detailed account of the work of culture diagnosis of diphtheria and the production of antitoxin is presented.

The total examinations made for the whole period have been 8,644; the lowest daily average for any month was 11, during August and September, and the highest 33, during December, 1895. The daily average of November, 1894, was 13; the daily average of November, 1895, was 28; of December, 1894, 27; of December, 1895, 33, — showing a marked increase in the use of this method of diagnosis by the profession.

The total number examined in November, 1894, was 397; in November, 1895, 835; in December, 1894, 823; in December, 1895, 1,023.

There were sent in 402 cases showing no growth, and these are to be neglected, leaving 8,242 cases in which the results were more or less satisfactory. Of these, 1,717 were found to contain the bacilli of diphtheria, a percentage of a little less than 21.

### *The Production of the Antitoxin of Diphtheria.*

The preparation of this material was begun in December, 1894, and has been vigorously and successfully prosecuted since that time. Some time was consumed in getting together the necessary apparatus, animals and assistants. The cultures have all been made and the injections of the horses have been carried out at the place originally selected on Gallop's Island.

The following table has been prepared, which includes the totals from all the horses in the time that they have all been immunized, i.e., from the last August, 1895:—

|                        | Cubic Centimeters<br>of Serum. |
|------------------------|--------------------------------|
| Horse IV., . . . . .   | 2,500                          |
| Horse V., . . . . .    | 3,500                          |
| Horse VIII., . . . . . | 1,700                          |
| Horse IX., . . . . .   | 2,000                          |
| Horse X., . . . . .    | 3,500                          |
| Horse XI., . . . . .   | 2,500                          |
| Total, . . . . .       | 15,700                         |

or nearly 1,000 cubic centimeters a week.

There have been returned at this date (Jan. 15, 1896) reports of the results of the use of the antitoxin supplied by the board in 743 cases, divided as follows:—

|                       |     |
|-----------------------|-----|
| Recoveries, . . . . . | 550 |
| Deaths, . . . . .     | 97  |
| Total, . . . . .      | 647 |

giving a mortality of a shade under 15 per cent., which is remarkable when compared with the general mortality of this disease, never under 27 per cent. in Boston and 27.06 per cent. in 1894.

To the foregoing are to be added 96 cases in which the serum was used for immunizing, making a total of 743 cases in all.

It has seemed to be interesting to work out the percentage of mortality in private practice, so far as it is shown by our returns. Of cases in which the antitoxin of your board has been used out of the hospitals, there have been reported:—

|                       |    |
|-----------------------|----|
| Recoveries, . . . . . | 72 |
| Deaths, . . . . .     | 7  |
| Total, . . . . .      | 79 |

which gives a mortality of 8 per cent.

#### *Garbage Disposal.*

If this material should be disposed of in the kitchen there would no longer be any danger of a public plant for the cremation or reduction of garbage in any residential district of the city; there would be no more ill-carts in the streets; there would be fifty thousand less swill-barrels in the back yards, and a saving of two hundred thousand dollars annually to our city treasury.

*House-to-house Inspection.**Recapitulation.*

|                                          |   |   |   |   |   |   |   |   |        |
|------------------------------------------|---|---|---|---|---|---|---|---|--------|
| Whole number examined,                   | . | . | . | . | . | . | . | . | 366    |
| Bad odors found,                         | . | . | . | . | . | . | . | . | 116    |
| Defective drains found,                  | . | . | . | . | . | . | . | . | 122    |
| Lack of traps found,                     | . | . | . | . | . | . | . | . | 77     |
| Offensive vaults found,                  | . | . | . | . | . | . | . | . | 1      |
| Damp or unclean yards,                   | . | . | . | . | . | . | . | . | 11     |
| Damp or unclean cellars,                 | . | . | . | . | . | . | . | . | 19     |
| Using furnaces,                          | . | . | . | . | . | . | . | . | 107    |
| Furnaces without proper air supply,      | . | . | . | . | . | . | . | . | 14     |
| Using steam heat or hot water,           | . | . | . | . | . | . | . | . | 8      |
| Water-closets found,                     | . | . | . | . | . | . | . | . | 364    |
| Old style or faulty water-closets found, | . | . | . | . | . | . | . | . | 64     |
| Offensive water-closets found,           | . | . | . | . | . | . | . | . | 34     |
| Ventilation to soil-pipe or drain found, | . | . | . | . | . | . | . | . | 178    |
| Offensive cesspools found,               | . | . | . | . | . | . | . | . | 14     |
| Percentage of defective drains,          | . | . | . | . | . | . | . | . | 33.33  |
| Percentage of defective trapping,        | . | . | . | . | . | . | . | . | 21.04  |
| Percentage of unventilated drains,       | . | . | . | . | . | . | . | . | 51.37  |
| Total number of nuisances abated,        | . | . | . | . | . | . | . | . | 11,679 |

*Disinfection after Infectious Diseases.*

|                               |   |   |   |   |   |   |   |   |        |
|-------------------------------|---|---|---|---|---|---|---|---|--------|
| Diphtheria,                   | . | . | . | . | . | . | . | . | 3,450  |
| Scarlet fever,                | . | . | . | . | . | . | . | . | 1,486  |
| Phthisis,                     | . | . | . | . | . | . | . | . | 6      |
| Measles,                      | . | . | . | . | . | . | . | . | 11     |
| Total,                        | . | . | . | . | . | . | . | . | 5,095  |
| Rooms disinfected,            | . | . | . | . | . | . | . | . | 10,155 |
| Grand total of disinfections, | . | . | . | . | . | . | . | . | 56,888 |

*Materials Used.*

|                                 |   |   |   |   |   |   |   |        |
|---------------------------------|---|---|---|---|---|---|---|--------|
| Bichloride of mercury (pounds), | . | . | . | . | . | . | . | 1,575  |
| Chloride of lime (pounds),      | . | . | . | . | . | . | . | 36,875 |
| Sulphur (pounds),               | . | . | . | . | . | . | . | 44,899 |
| Copperas (pounds),              | . | . | . | . | . | . | . | 3,150  |
| Muriatic acid (carboys),        | . | . | . | . | . | . | . | 12     |
| Houses ordered vacated,         | . | . | . | . | . | . | . | 112    |

*Public Baths, Number of Bathers in June, July, August and September.*

|                        | 1894.     | 1895.   |
|------------------------|-----------|---------|
| Total men and boys,    | 860,944   | 589,779 |
| Total women and girls, | 221,731   | 177,046 |
| Total of both sexes,   | 1,082,675 | 766,825 |

The subject of maintaining bath-houses all the year round was the subject of a special recommendation by His Honor the mayor in his inaugural address to the city council, and a special commission has since been appointed by him to consider the subject, and make such recommendations with a view to establishing such accommodations as may be deemed expedient. The supplying of public bathing facilities during the winter as well as during the summer months has the cordial approval of the board of health, as being in the line of promoting the public health.

#### *Examination of Plumbers.*

The examining board held 44 meetings and examined 258 candidates for plumbers' licenses; 93 were for master plumbers' licenses, and 50, or 52 per cent., passed the examination and were licensed; 165 were examined for journeymen plumbers' licenses, and 106, or 64 per cent., passed the oral examination and were notified to report at the shop for a practical test. Of the 106 candidates who passed the oral examinations, 77 passed successful examinations in the shop and were given licenses.

#### *Lying-in Hospitals.*

During the year 423 confinements have taken place in the licensed hospitals, and no deaths have been reported.

#### *Stables.*

There were 248 applications, and 198 were granted.

#### *Prosecutions.*

During the year there have been 30 prosecutions for violations of various health laws. In these cases there were 25 convictions, 2 acquittals, 2 were *vol-prossed* and 1 is still pending.

Of the convictions, perhaps the most important was that of a physician for failing to report a case of contagious disease which he had been called to attend. In this case a fine of fifty dollars was imposed in the lower court, and, after an appeal and trial before a jury, the judgment of the lower court was affirmed, and the fine increased to one hundred dollars.

The physicians of the board examined 39 cases reported as small-pox, one of which proved to be such.

The bodies of 454 persons dying without a physician were also examined, determine the causes of death.

#### *Animals killed at Abattoir.*

|                   |        |
|-------------------|--------|
| Cattle, . . . . . | 25,814 |
| Calves, . . . . . | 14,141 |
| Sheep, . . . . .  | 77,906 |
| Swine, . . . . .  | 470    |

*Animals condemned.*

|                             | Number. | Weight. |
|-----------------------------|---------|---------|
|                             |         | Pounds. |
| Cows, . . . . .             | 52      | 22,864  |
| Steers, . . . . .           | 2       | 1,540   |
| Bulls, . . . . .            | 1       | 630     |
| Calves, . . . . .           | 9       | 372     |
| Sheep, . . . . .            | 1       | 30      |
| Parts of animals, . . . . . | —       | 4,000   |
| Total, . . . . .            | 65      | 29,436  |

*Diseases found among Animals after having been killed and dressed at the Abattoir.*

| DISEASES.                  | Cattle. | Calves. | Sheep. |
|----------------------------|---------|---------|--------|
| Tuberculosis, . . . . .    | 49      | —       | —      |
| Actinomycosis, . . . . .   | 7       | —       | —      |
| Septicæmia, . . . . .      | 2       | —       | 1      |
| Puerperal fever, . . . . . | 2       | —       | —      |
| Bruised, . . . . .         | 1       | —       | —      |
| Immatured, . . . . .       | —       | 9       | —      |

*Tuberculosis.*

The following table shows the percentage of tuberculosis in cattle killed at abattoir with the intention of being used for food :—

| CLASS OF ANIMALS.                     | Number received. | Tuberculosis. | Percentage. |
|---------------------------------------|------------------|---------------|-------------|
| Whole number of all kinds, . . . . .  | 25,814           | 49            | 0.189       |
| Cows from eastern States, . . . . .   | 1,949            | 47            | 2.41        |
| Bulls from eastern States, . . . . .  | 157              | 1             | 0.63        |
| Steers from eastern States, . . . . . | —                | —             | —           |
| Cows from Buffalo, . . . . .          | 536              | 1             | 0.18        |
| Cows from western States, . . . . .   | 1,421            | —             | —           |
| Steers from western States, . . . . . | —                | —             | —           |

Under the head of "cows from eastern States" is understood those animals from all of the New England States, including Massachusetts.

*Inspection of Cattle.*

In accordance with the regulations of the board of health and an act of the Legislature, the work of inspection of cows kept for the production of milk has been continued during the past year. With one or two exceptions all cattle which upon inspection have shown any symptoms of tuberculosis have been subjected to the tuberculin test, and all animals which have shown a reaction to such test have been quarantined, and the State Board of Cattle Commissioners notified.

## BROCKTON.

The board is of the opinion that final disinfection after contagious diseases, which is required under the Public Statutes to be done to the satisfaction of the board, should be done by the board itself. It is the intention of the board the coming year to ask for an appropriation to carry out this work, and to employ some person to disinfect all premises and articles which, in its opinion, have been infected.

The following is a list of some of the principal complaints and nuisances investigated during the past year:—

|                                |     |
|--------------------------------|-----|
| Defective cesspools, . . . . . | 127 |
| Defective vaults, . . . . .    | 115 |
| Filthy yards, . . . . .        | 143 |
| Filthy cellars, . . . . .      | 24  |
| Bad drainage, . . . . .        | 33  |
| Animals buried, . . . . .      | 43  |

## BROOKLINE.

Nine cases of typhoid fever, several of which, if not all, were found on investigation to have been contracted away from home, is an exceedingly small number for a population of over sixteen thousand, and is the best possible evidence of the care taken to maintain the purity of our public water supply.

The board of health hospitals have been kept in readiness throughout the year, and have been used for the efficient isolation and care of 2 cases of scarlet fever and 21 cases of diphtheria. The only death occurring in the hospital was the case of a feeble little child, ill with both measles and diphtheritic croup, the latter disease being well advanced and beyond control when admitted to the hospital.

It is gratifying to be able to state that during the diphtheria epidemic in Brookline and the surrounding cities and towns in October, November and December, of the 18 patients admitted to the hospital, all going with their parents' approval or consent, and all of whom received one or more injections of antitoxin (in most cases furnished by the State Board), all re-



covered. The number of diphtheria patients reported in the town during the same time, many of whom also had antitoxin, was 42, of which number 9 died, or 21.4 per cent. During the epidemic and since, antitoxin has been furnished free by the board, on application, to physicians having patients who could ill afford to pay for it. The State Board antitoxin was supplied when available, otherwise Behring's, and excellent results were reported from both.

The value of the bacteriological test as a means of certain diagnosis, which is required to be made in all diphtheritic cases before they are released from quarantine, has been emphasized by the recent experiences here.

The need of improved public bathing facilities and of a new public swimming-bath, recommended in previous reports of this board as an important sanitary measure, has been recognized by the town, and the necessary steps for securing a new public bath-house, first-class in every respect, have been taken.

In the same pamphlet with the report of the board of health are published the reports of the inspectors of milk and of animals, also those of the sanitary inspector and of the town clerk on vital statistics. The report of the milk inspector presents the results of analysis of each one of more than two hundred samples, together with the names of the dealers.

#### CAMBRIDGE.

|                                             |       |
|---------------------------------------------|-------|
| Number of inspections made, . . . . .       | 2,313 |
| Number of subsequent inspections, . . . . . | 4,569 |
| Total, . . . . .                            | 6,882 |

#### *Hospital.*

In the year 1894 the prevalence of scarlet fever in Cambridge was greater than in any year since notification of diseases dangerous to the public health was made obligatory, and in the present year the same has been true of diphtheria.

Had there been during these years a suitable hospital for the reception of cases of these diseases at the disposal of the board, many cases might have been prevented and lives been saved. In the absence of such a hospital it has been the duty of this board (P. S., chap. 80, sect. 40), in view of the great prevalence of diphtheria in the city, to utilize as far as possible the small ward in the Cambridge Hospital for the reception of cases of this disease. They have also been compelled to use for a short time the Cottage Hospital on the almshouse grounds. While the accommodations afforded by these hospitals have not been adequate to the needs of the city, they have yet been of very great value in enabling us to check the spread of this disease. In these two hospitals combined 62 cases of

diphtheria have been cared for this year at the public expense; of this number, 9 died. The Cambridge Hospital also treated 9 private cases, among which there were no deaths. The fatality among the hospital cases was, therefore, 9 out of 71, or 12.7 per cent. Of these fatal cases it should be said that 3 were practically past hope when they reached the hospital, and expired shortly after reaching it.

#### *Disinfection.*

We are endeavoring to so train certain of our employees that the work of house disinfection may be intelligently and effectively done by them and under their direction, they being authorized to require the co-operation of the householders for such matters as can and should be done by the latter.

#### *Bacterial Examination.*

We are most clearly of opinion that the protection of the public health demands that this work, begun by this board during the past year, should be unremittingly carried on.

#### *Schools.*

What has thus far been accomplished is to prevent the return to the public schools of children who have had contagious disease, while they are yet capable of transmitting it, and to prevent the attendance at such schools of children from families wherein cases of such disease exist. This has been of the utmost importance; but there yet remain the following measures to be adopted before it can be said that the city has reasonably done its duty in the premises:—

1. The extension of the present system to the private and parochial schools of the city.
2. Establishing a system of school inspection by physicians appointed by this board, with a view of detecting cases of actual disease among the children present in school, and their prompt elimination.
3. Much greater attention than has heretofore been paid to the matter of cleansing of the school-rooms and school-houses.

We have already succeeded in partially extending this system to the parochial schools; i.e., notification of contagious diseases affecting the attendance of their scholars is now sent to those in charge of such schools.

#### CANTON.

Owing to an informality in the election of the board of health, the duties of the office devolved upon the selectmen.

Twenty-three complaints of nuisances have been filed, and each was at once abated.

## CHICOPEE.

Epidemic influenza, or "grippe," which appears to have become an annual visitor, was the principal acute disease affecting our people during the winter and spring, but, aside from its fewer victims and somewhat lessened severity, presented no new symptoms worthy of note.

Eight cases of typhoid fever is a good record, compared to the years previous to 1893, when our city stood among the first in the Commonwealth as a habitat of this disease. Here certainly is a testimonial to the greater cleanliness of the city, as well as to our better water supply. Some difficulty has been experienced in getting physicians to report cases of typhoid to the health department, though this is distinctly required by the regulations. Accordingly the board had mailed to every physician in the city a postal card *stating that typhoid fever must be reported*, that this was necessary not only for statistical purposes but also to enable the health authorities to investigate the sanitary conditions of the places where it occurred, and that co-operation in this matter would be insisted upon. Since then, so far as the board is aware, all cases have been promptly reported.

As our population increases, the need of some systematic and reliable method of garbage collection becomes more pressing.

## CLINTON.

The board has made arrangements with the State Board of Health for the keeping of a supply of antitoxin on hand for the use of physicians in this and adjoining towns. By this means several cases in Clinton and Bolton have been supplied earlier than could have been the case under the former method, and it is believed with marked benefit.

## COHASSET.

Complaints having been made of the impure condition of James Brook during the summer, the board of health carefully investigated the matter and did what they could to abate the nuisance. Believing the cause to have been the flowing of sewage into the brook, they requested all persons who convey the overflow of their cesspools thereto to cease doing so before April 1 next. A cheerful compliance with the above request will prevent the repetition of the nuisance the coming summer. The board have, as a precautionary measure, caused the brook to be cleaned and dug out from the bridge on Pleasant Street to its entrance to the harbor.

## CONCORD.

The plumbing in thirty-six houses has been inspected and passed during the year. This work is all new, being either in new houses, or new work in old houses. We can truthfully say that that part of the labor of this

board is worth all it costs. In our opinion this is most important, and it will be found to be especially so if a system of sewage disposal is established in the near future. By the agent's report it will be seen that he has inspected more places than ever before, and in the most thorough manner.

The agent was refused permission to inspect the premises in one case. The deputy superintendent of the Massachusetts Reformatory, acting under instructions from the superintendent, took the ground that none of the houses occupied by the officers and owned by the Commonwealth were subject to any inspection by the local board of health. After considerable correspondence with the superintendent and the prison commissioners, an opinion was finally obtained from the Attorney-General of the State. The opinion is expressed that, as the superintendent had sole control of the reformatory, and as the houses of the officers were a part of the institution, the local board of health could not inspect them without interfering with the discipline of the prison. It being admitted on our side that we had no rights inside the prison walls, the Attorney-General thought that it would be impossible clearly to draw the line, and hence that neither we nor the State Board had any right to inspect the property. We have rested our case there. Our only alternative is to go to the Legislature and try to get a bill passed, allowing local boards of health to inspect State property used as dwellings, wherever it may be found within their jurisdiction.

It seems to us decidedly inconsistent that, as a local board, we should not have the same rights to inspect the houses of the Commonwealth as we have to inspect those of a private individual; for, if an epidemic should break out, or even if an isolated case of contagious disease should appear in one of the houses owned by the Commonwealth, the local board of health would certainly be called upon to fumigate the building and take other measures to abate the trouble, and, if so, why should we not have the power to inspect the houses at first, and see that they are kept in a healthy condition?

#### COTTAGE CITY.

As there had been considerable agitation and discussion concerning the unsatisfactory condition of Lake Anthony for some time previous to the annual town meeting, at which place it was again brought under discussion, the board felt it their duty to bring the lake into as clean and healthful a condition as possible, and at the same time render it an ornament to the town. The board, therefore, consulting with several competent persons as to the most expedient and satisfactory way to obviate this difficulty, decided to close the opening to the lake, thereby changing the water from salt to fresh, and thus killing the peculiar growth of grass with which the lake was filled, and by its decay causing a disagreeable odor, rendering the shore unsightly and making the lake totally unfit for boating. We closed

the lake by the construction of a dam across the opening, by which means the water was changed from salt to fresh. We succeeded by this means in destroying the grass, as evidenced by the large quantities which came ashore during high winds, and the accumulation thus coming ashore was raked up and carted away as soon as possible.

#### DANVERS.

There was an epidemic of measles during the spring and summer, probably many more cases than were reported, as the disease is often so mild that no physician is called to attend.

The cases of diphtheria were treated with the new remedy, diphtheria antitoxin, of which so much has been expected. We have thought it advisable to keep an antitoxin syringe and a supply of antitoxin on hand, so that any physician in town can obtain them of the board of health at short notice.

The time is not far distant when the town must adopt a general sewage system, which is the only satisfactory way of disposing of the sewage in thickly settled parts of the town.

#### DEDHAM.

The town is to be congratulated, both in being able to obtain so excellent a service as will be hers when the metropolitan sewer is completed, and also in having the prospect of obtaining so speedy a relief from the extremely unsanitary conditions now prevailing in her midst. Upon the completion of the trunk sewer the town must construct a system of lateral or branch sewers to connect therewith, and some provision must be made for this purpose in the near future.

The keeping of swine in the town and the teaming of swill and offal through the streets seem to be an annual source of difficulty and nuisance.

#### EVERETT.

In July it came to the knowledge of the board that there were some unreported cases of diphtheria. The attending physician was prosecuted and fined fifty dollars in the district court. In these cases the probable source of infection was an old lounge that had been brought from out of town and upon which a child had died with diphtheria. It was put out in the yard, and the children had used it. Very soon there were 7 cases and 1 death in the neighborhood. Possibly there were other mild cases that were not recognized. There has been a number of cases since in that locality. In a number of instances we are quite sure that the disease has been contracted from infected persons from out of town or by children visiting infected houses in other places. In one case a child was sent here because its brothers had the disease. This child remained well, but a child in the

family where it came to stay developed a positive case of diphtheria. We have had a number of cases that have shown the great advantage of making bacteriological examinations. Of 26 cases where antitoxin was used early there were but 2 deaths (one of them occurred at the end of the sixth week), — a mortality of 7.7 per cent. In four cases it was used late, and the patients died. Of the 25 in which it was not used, 11 of the patients died.

Everett is a city of new, clean houses. We have a third less tuberculosis than the average of the State. By care and disinfection we can keep these houses free from the germs of this disease.

#### FALL RIVER.

Many cases of contagious diseases have come under our observation in homes and boarding-houses where there were not proper facilities for their care and isolation. We believe the safety of the public demands that some provision for such cases should be made, and would recommend that a ward in the old almshouse be set apart for the treatment of contagious diseases of this character, other than small-pox.

The increase in contagious diseases for the year, before noted, was altogether confined to scarlet fever and diphtheria, and was not wholly unexpected, as in the early spring and during the year those diseases were reported as prevalent, and even epidemic, in many cities of the Commonwealth as well as the surrounding States, from which the board knows some of the cases reported in this city were brought, and has reason to believe there were others.

Early in the year the board decided that it would be necessary to take energetic measures to stamp out those diseases, or prevent them becoming epidemic, and result in the closing of the public schools, as occurred elsewhere. Regulations were adopted, printed and furnished to all physicians and undertakers, and, through the superintendent of schools, the teachers of the public schools were also notified of the same.

In all cases of diphtheria, culture tubes are furnished by the board to the attending physician, to take cultures from the throat of the patient.

Our only protection against small-pox consists in thorough vaccination. This the board provides free of expense, and advertises freely, which we are gratified to note by the records is understood and appreciated by our metropolitan population, the number vaccinated each year exceeding the previous one. Vaccinations are performed by the clerk of the board, under the direction of the city physician. The number successfully vaccinated each year during the past four years was as follows: 1892, 1,326; 1893, 231; 1894, 1,720; 1895, 2,118.

While the primitive method of disposing of garbage, as pursued here, might for a time be permitted in a country town, where it could be conveyed to some uninhabited outlying district, it seems needless to add that

it is in no way adapted to a city of ninety thousand inhabitants. With a view to be able to suggest at this time the safest and most approved system of disposing of garbage, the board, agent and inspectors have visited different cities during the year, for the purpose of investigating their systems. The result of our inquiries confirms the opinion that destruction by fire is the only sure and safe method of disposing of garbage.

Ten cows were found to be infected with tuberculosis during the year, and, after the usual quarantine and inspections by the cattle commissioners, were destroyed, and the carcasses disposed of to the satisfaction of the board of health. In May last the board adopted a regulation requiring the owners of all neat cattle within the city to have the same duly registered and licensed at the office of the board of health every year. The reason that led to this was the number of cases coming to our notice of ill-fed cattle, allowed to roam through the streets and feed upon garbage among the different dumps throughout the city, as well as the filthy condition and lack of ventilation in the stables in which they were housed (when housed at all).

#### FITCHBURG.

House inspection has been extended, during the past year, over sections of the city contiguous to those sections inspected in 1894, and has included also the whole section, called the south Fitchburg district, which was the seat of the diphtheria epidemic. The total number of inspections recorded was 554.

The total number of nuisance complaints received by the board during the year was 148. This includes only the complaints of which a record is made. In connection with the regular house inspection, a very large number of minor unsanitary conditions were found and corrected by a personal notice.

The majority of the cases of diphtheria occurred in a section of the city which is in no way provided with sewers and proper means of drainage. It cannot be said, however, that the unsanitary conditions found in nearly every house where the disease occurred were the direct cause of the outbreak, as an infection from case to case was in nearly every instance traced. In all cases where defects were found the property owners were asked to correct them so far as possible, and in nearly every instance they readily and promptly complied. A very good map, showing the location of cases, accompanies the report.

Typhoid fever has been somewhat prevalent during the year, although the total number of cases was not greatly in excess of 1894. Out of a total number of 29 cases, 7 may fairly be said to have been imported,—the origin of the disease having been traced to infection arising in other places than Fitchburg. More than usual care has been exercised the past year in getting as accurate a history of each case as was possible.

## FRAMINGHAM.

The State Board of Health was consulted in reference to the cases of typhoid fever occurring in South Framingham, a suspected well of water was examined, and all infected premises ordered cleaned and disinfected. The outbreak could be traced to two imported cases.

## GARDNER.

The sanitary condition of the town is the best that it has been within our memory. Places that in former years were frequently neglected are now being regularly attended to, or are improved so as to avoid frequent complaints. We believe that prompt attention to complaints has led to this gratifying result, and the people of the town derive the benefit in being comparatively free from contagious diseases.

With a town of ten thousand inhabitants, the milk supply is one of great importance. Since the board recommended that those furnishing the supply should obtain licenses, we find that there has been a steady improvement in the care of stock, and, the natural result, an improvement in the milk supply. There have been forty-eight licenses granted during the past year.

## GLOUCESTER.

There have been more cases of scarlet fever and diphtheria during the past year than on some previous years, but the type has generally been mild.

The board would recommend the maintenance of a hospital for contagious diseases.

## HAVERHILL.

The most noticeable contrast in the mortality of any infectious disease between last year and previous years is the number of fatal cases of whooping-cough. Physicians are very careful to report their cases of diphtheria and scarlet fever, but little attention is paid to reporting cases of whooping-cough. The records show that only 34 cases have been reported, and of this number 12 deaths occurred last year. This would be more than 35 per cent. of the number reported, — a higher death rate than for any other disease that was reported to us. It is probable that, instead of there being but 34 cases, as reported, in the city last year, there were many more than that number. In the last twelve years, including 1895, there have been, in all, but 31 fatal cases of whooping-cough, an annual average of less than 3 deaths.



## HOLYOKE.

The board is of the opinion that a crematory necessary for the accommodation of the city's offal, and located in a convenient place, would be more economical to the city than the course now pursued.

Early in May a thorough health inspection of the city was made by the board of health. Several localities of doubtful healthfulness were promptly corrected in a measure satisfactory to the board. The importance of this annual sanitary inspection regularly and systematically carried out in the early season of each year cannot be over-estimated. It stimulates the habitually careless to a better regulation of their houses, and removes from unsanitary localities much that invites and fosters disease germs for summer activity. On persons not complying with the board's orders in regard to abating nuisance, eight sheriff's notices were served; conviction and fine was the result of each case.

Out of a mortality of 111 deaths during the month of July, 79 deaths were among infants.

## HYDE PARK.

About one hundred and fifty complaints have been received in relation to overflowing cesspools, vaults in bad condition, wet land, filthy houses and yards, dead animals, and swine kept without permits.

There has been quite an increase in the cases of contagious diseases, although in some respects we have fared better than some of the towns about us. The increase in cases of measles has given a large total for this year. We find that in cities and towns where a hospital is provided patients receive in most cases better care, the contagion is less liable to spread and deaths are less frequent. We hope the time will come when we can have this help in our work.

## IPSWICH.

During the months of October and November an epidemic of measles spread through the town. The disease was of a mild type, and no deaths occurred from the same. With these exceptions, the general health of the town has been fairly good. But how much longer this will continue is a question, and one to be seriously considered; for with our public water supply and our town being so situated in a valley, so to speak, and our drainage at the best none too good, the filth that will accumulate in numerous cesspools will prove a dangerous menace to the public health. The complaints to the board for the past year have been mostly from this cause, and absolute safety from cesspool filth will never be attained until the town provides a system of sewerage.

## LEE.

the board as a body, or by delegating one of its members, investigated complaints received regarding nuisances or conditions detrimental to the health whenever there seemed reasonable ground for such complaints; in all cases the recommendations or orders of the board were promptly and apparently cheerfully complied with.

## LEXINGTON.

In several years past the piggeries in various parts of the town have at times given considerable trouble. The present board, after careful consideration, adopted the system of giving permits for the keeping of swine, a practice which has thus far given very good satisfaction. The whole number of permits granted is sixteen, the board finding it unnecessary to issue permits for a less number than twenty pigs.

## LOWELL.

|                                |   |   |   |   |   |   |            |
|--------------------------------|---|---|---|---|---|---|------------|
| Cost of burning garbage, 1894, | . | . | . | . | . | . | \$5,742 69 |
| Cost of burning garbage, 1895, | . | . | . | . | . | . | 3,662 53   |
|                                |   |   |   |   |   |   | <hr/>      |
| Saving in 1895 of              | . | . | . | . | . | . | \$2,080 16 |

The ashes resulting from the combustion of our garbage have frequently been analyzed at the State Agricultural College at Amherst. The analyses show that to a certain extent summer ashes appear to be poorer than those of spring or fall. The largest amount of potassium oxide per 100 parts of ash found in a specimen of the ashes was 8.83; the largest amount of phosphoric acid was 32.36.

The only way to obtain a satisfactory solution of the problem, how to dispose of a city's garbage is to make a thorough personal investigation of all the methods now in use. Such an investigation has been made under the direction of Mr. Rudolph Hering, the well-known civil engineer, and chairman of the committee on disposal of garbage of the American Public Health Association.

At the same time, the conclusions reached by the board of health from a five-years study of the subject are briefly as follows:—

That reduction systems, even if well located, properly constructed and carefully managed, can at present offer no marked improvement over crematories.

That, at present, cremation is the best solution of the problem for the large New England city. That the kind of cremator to be selected

should have been in active operation for at least a year in some city where it has caused no nuisance.

That trustworthy figures should be obtained as to the average cost in fuel and labor to burn a ton of garbage, and that the price of fuel and labor should be known.

That that cremator should be selected which, considering the original cost, will do the city's work most efficiently and economically.

That it should be owned and operated by the city.

That the cremator now in use in Lowell is a vast improvement over the methods employed in all other New England cities.

A contagious disease hospital is recommended.

The board of health recommends, and the citizens can if they desire see, that Lowell is provided with a public bath-house.

As regards the use of antitoxin in diphtheria, we find from our limited experience somewhat more favorable results from the use of the remedy than by other means of treatment.

#### LYNN.

During the year there has been completed on Holyoke Street a hospital for contagious diseases, in accordance with chapter 511 of the Acts of 1894. This property was turned over to the board of health by the proper committee April 29, 1895. It was dedicated and opened to the admission of patients May 15, 1895, the administration building and two hospital wings, consisting of two wards each, receiving suitable furniture throughout as a gift.

The first patient was admitted June 13, and the total number admitted to Jan. 1, 1896, was 40. The first case of scarlet fever was admitted June 13, and the number of cases was 12. The first case of diphtheria was admitted August 14, and the number of cases was 27. One case of measles was admitted July 7. Of the 40 patients admitted, there have been 3 deaths, all from diphtheria, or about 11 per cent. of the diphtheria cases admitted, or a little more than 7 per cent. of total admissions.

As soon as possible after a patient suffering with diphtheria has been admitted to the hospital diphtheria antitoxin is administered, which has a pronounced curative effect upon the disease. The use of this remedy is responsible for making the mortality so low the past six months in this institution. In two of the patients that died the disease had been in progress six days before the remedy was administered. In the third patient, beside being a late stage of the disease, there was some complication which was not positively recognized. The first two patients died twenty-four and thirty-six hours after admission, and the third thirty-six hours after admis-

1. To my mind, all three of these patients could have lived had the administration of antitoxin been effected in the early stages. Comparing my experience with that had in 1893, when diphtheria appeared in the children's home, there were 3 deaths in 10 taken with the disease, or a mortality of 30 per cent.; this was before antitoxin was used in this country.

#### MARLBOROUGH.

There has been no serious outbreak of disease in the city during the year. In November a rather small epidemic of measles appeared, and about sixty cases were reported to the board.

The cases of scarlet fever and diphtheria were few and somewhat widely scattered in time of appearance and in location.

Early in the year the board discussed the matter of furnishing to the physicians of the city means for a culture diagnosis in cases of diphtheria. Although the opportunity to test the value of this method of being positive diagnosis in cases of contagious disease has been small, there being only a few cases of diphtheria during the year, the board is much pleased at the results of its experience. In the summer vacation a very severe case of diphtheria appeared, after an interval of five months in which no cases had been reported. By chance it was discovered that a boy who had lately come from a neighboring town, from a house where there was a case of diphtheria, was staying on the opposite side of the street. This boy had been dinner some days previous with the patient now sick with diphtheria. A culture examination of the throat of the suspected importer of the disease showed that his throat contained germs of diphtheria, though he had at any time been sick in bed nor in doors, nor had he paid any attention to his sore throat. No doubt he was the bearer of the disease to the aforementioned patient. These cases are mentioned to call the attention of the public to the fact, not generally understood, that a person may be suffering from diphtheria in a mild form, and not necessarily be sick in bed, but at the same time be capable of conveying the disease in its worst form to another individual.

The antitoxin furnished by the State Board of Health was used by the physicians attending diphtheria cases in only two instances. Each time there seemed to be a reluctance on the part of the physician to use the new remedy until other means of treating the disease had been tried. This is the course recommended by those who are familiar with the best results of antitoxin treatment, and it is hoped that physicians who decide to use antitoxin will give the remedy a fair trial by using it as early in the case as possible.

There were one hundred and seventy-one complaints of nuisances received during the year. These were promptly investigated. A few legal actions were served.

## MEDFORD.

In our report of 1894 attention was called to the fact that the existence of diphtheria can be positively recognized at an early stage by the modern methods of microscopical examinations. Following our recommendation, the sum of one hundred dollars for the special purpose of providing such examinations was generously granted, and during the past year thirty-one cultures from suspected cases of throat disease have been examined either at the Harvard or Tufts medical school laboratories, with the following results: number of examinations, 31. The bacillus of diphtheria was found in 23 examinations; the bacillus of diphtheria was not found in 8 examinations. It is thus to be seen that, of 74 cases reported as diphtheria, in fully 50 cases no microscopical examination was made.

In the opinion of this board, each report of a case of diphtheria, with its consequent discomforts of isolation, disinfection, etc., should be founded upon, and verified by, a proper microscopical examination.

## MELROSE.

Our requirements to correct nuisances have usually been promptly met. One person only has been brought to court and fined for offence, and he for not only emptying his cesspool himself without a permit, but for the gross misdemeanor of pouring the offensive material upon his neighbor's premises. A number of languid responses to our requirements have been wonderfully quickened by the impending resort to legal proceedings.

A concise summary of the labors of the inspector of plumbing during the past year is as follows:—

|                                           |           |     |
|-------------------------------------------|-----------|-----|
| Number of permits granted to do plumbing, | . . . . . | 492 |
| Number of permits for sewer connection,   | . . . . . | 166 |
| Number of visits made by inspector,       | . . . . . | 833 |
| Number of water tests made,               | . . . . . | 424 |
| Number of sewer connections tested,       | . . . . . | 129 |

## NEW BEDFORD.

For the past year every case of typhoid fever, diphtheria and scarlet fever has been investigated, with the idea of keeping a record of each case, and trying to impress upon the public the necessity of greater care in isolation and sanitation.

The school which each child attends is ascertained, together with the special room, and if several cases are found originating at about the same time in any one room, then that room is closed and thoroughly disinfected, and reopened again at the judgment of the board of health. Three times during the past year this has been done, probably stopping what at first

appeared to be the beginning of a serious epidemic of scarlet fever and diphtheria. The Sunday-school attended by the sick child is also inquired into, and the superintendent of that school notified of the fact of that child's illness, with the advice to stop future attendance of other children in the same family. Each case of scarlet fever is watched until desquamation has ceased, although no school permits are given until after four weeks have elapsed, even though that process should have apparently ceased earlier.

During the year about 550 calls have been made by the inspector. Nineteen vessels coming from foreign ports boarded by quarantine physician; none quarantined.

#### NEWTON.

Upon recommendation of His Honor the mayor, the city council, in June, appropriated the sum of one thousand dollars for the erection and maintenance of a bath-house on the bank of Charles River, off California Street, Ward 1. The committee on public property were instructed to erect the building, which, when completed, was to be turned over to this board to maintain.

The general health of the city during 1895 has compared favorably with previous years, the number of deaths being 448, a mortality of 16.23 per thousand. No general epidemic has occurred, although from some of the wards a large number of contagious cases were reported. The three important contagious diseases, diphtheria, scarlet fever and measles, have been present in the city almost continuously during the year, but never in such number as to cause serious alarm. As will be seen by the tables, the number of cases of diphtheria reported to the board was greatly in excess of the previous year.

The great benefit to the city of the contagious wards of the Newton Hospital has again been fully demonstrated, 121 cases of contagious disease having been admitted. The board has always urged, and in some cases compelled, parents to send their sick children to the hospital. This is one of those instances when the prerogative of the board seems to antagonize individual liberty; but it is the duty of a board of health to do all in its power to prevent the spread of a contagious disease, and, as by removing a sick person from a crowded tenement more can be done toward freeing the community from danger than can be accomplished by the strictest quarantine, the individual must yield to the community.

The plan of appointing medical inspectors for each ward or school district, on whom the board can call to examine the children in a school or elsewhere, in the event of suspected cases, has worked most satisfactorily. Several school inspections have been made, and a large number of children have been examined at their own homes by the inspectors; in several instances unsuspected cases of disease have been discovered and reported to

the board, thus enabling it to take proper precautions. No complaint in regard to the interference by the inspectors with the work of the family physician has been reported, and the board will continue the system during the coming year.

On Jan. 1, 1895, the board announced that it would furnish antitoxin free of charge to physicians who wished to use it in the treatment of diphtheria. Advantage was immediately taken of this offer, and the board continued to supply it until the State Board of Health was able to meet all demands.

The use of antitoxin in the treatment of diphtheria may be said to have become general in Newton after this offer made by the board. Previous to that several cases had been treated with it, but they were too few to permit any inference to be drawn as to its value. Since then the board has endeavored to keep careful statistics of the results of its use, and the figures given herewith are of great interest. To show most conclusively the effect of antitoxin upon the death rate in diphtheria, it is necessary to compare the rate in 1895 with that of previous years. Starting in 1890, it is found that the death rate from diphtheria in Newton is as follows:—

| YEAR.           | Cases. | Deaths. | Rate. |
|-----------------|--------|---------|-------|
| 1890, . . . . . | 55     | 10      | 18.18 |
| 1891, . . . . . | 42     | 7       | 16.66 |
| 1892, . . . . . | 29     | 8       | 27.50 |
| 1893, . . . . . | 88     | 32      | 37.27 |
| 1894, . . . . . | 81     | 20      | 24.69 |

The figures for 1895 are as follows:—

|                 |     |    |      |
|-----------------|-----|----|------|
| 1895, . . . . . | 151 | 15 | 9.93 |
|-----------------|-----|----|------|

In accordance with an order of the city council, the board considered the subject of establishing a steam plant for the disinfection of bedding, mattresses, etc., from houses infected with contagious disease. A report on this subject was made early in the spring, and the board again calls attention to the necessity for such a plant in order to prevent the spread of contagion through the inability of the board to properly disinfect such articles.

#### NORTHAMPTON.

We have no hospital for contagious diseases. A suitable location for one has been found in the rear of the almshouse property, across the track, safe from danger of contagion. A one-story wooden building costing but a small sum is needed in our city.

## NORTH ATTLEBOROUGH.

North Attleborough has enjoyed a comparative freedom from diseases of a contagious character during the past year. Any cases that have appeared have been quarantined at once, when the board has been notified of their existence. In each case, when quarantined, there has been no spread of the disease beyond the domicile where it first made its appearance. The neglect of one family in failing to ascertain the true character of the sickness of one of its members caused the board to fear that there might follow an epidemic of scarlet fever, since the child had been allowed to mingle with other children. Fortunately, only one other case followed as a result of this neglect. The board feels called upon to once more demand of parents that they should consult some competent authority in case of any suspicious sickness, especially among children.

## PROVINCETOWN.

The inspectors of the board of health have visited about eight hundred houses, and in nearly all found marked improvement in condition over last year. We have also visited the schools, and found the temperature quite even, but the system of ventilation very poor indeed, and would recommend that it be improved in some way during the coming year.

The vaccination law has been thoroughly enforced in our schools, with the result that over four hundred children have been vaccinated; each of these, together with all those who had been previously vaccinated, was resented with a certificate to be given to the superintendent, that a thorough and complete record may be kept of the same.

## QUINCY.

One of the earliest matters to receive the attention of the board was the importance of improving the scavenger system of the city. Complaints by citizens and the personal knowledge of the workings of the old system led the board to consider the desirability of adopting a more cleanly and responsible system than had previously prevailed. Testimonials and visits to neighboring cities where the contemplated system was in practical working order led the board to adopt the Odorless Excavating Company's system.

## SALEM.

In two cases this year it has been necessary to close schools until a complete disinfection could be had, and books, pencils, etc., likely to spread the infection, destroyed. So little did some persons realize the importance of thus protecting the children, that some adverse criticism followed because of the loss of the value of the books, which, however, was quite inconsiderable.



The board has encouraged in every practicable way the use of the new remedy, antitoxin, and with very gratifying results. The length of the disease, in cases where this remedy was used, has been much reduced, and in some cases lives have been saved which in all probability would have been lost under any other treatment. Of the four fatal cases, two were treated in this way and two were not.

#### SOMERVILLE.

|                                                                        |     |
|------------------------------------------------------------------------|-----|
| Number of nuisances abated, . . . . .                                  | 814 |
| Number of nuisances referred to board of 1896, . . . . .               | 173 |
| Number of nuisances complained of, . . . . .                           | 987 |
| Number of complaints (many covering more than one nuisance), . . . . . | 507 |
| Number of notices mailed, . . . . .                                    | 480 |
| Number of notices served by constables, . . . . .                      | 19  |

In addition to the above, many nuisances have been abated on verbal notice from the agent without action by the board, and of which no record has been made.

Six cases of glanders have occurred during the year. Prompt action was taken in every case, and the horses have been killed.

#### TAUNTON.

The board has advocated the isolation of suspected cases of diphtheria, especially where there are two or more children in the family or house, without waiting for a full development of the disease.

Early in the year the board of health invited the co-operation of the school teachers to aid in preserving the public health. To this end printed postal cards directed to the board of health were distributed to each teacher, whereon they were to indicate the absence of any pupil with suspected illness. Upon receipt of the card the physician of the board visited the scholar. A large number of cases so indicated have been examined, and, while a large majority of cases found were of the kind incident to childhood, suspicious cases of contagious disease have been found, the child isolated and children in the house kept from school.

#### WAKEFIELD.

Regulations for the inspection and testing of plumbing work were made and have been enforced. The result has been highly satisfactory, the quality of the work done being so much improved as to far outweigh the additional cost to the town of having the inspections made. We wish to impress upon the town the absolute necessity of some sewerage system in the very immediate future, as there are in certain portions of the town nuisances that cannot be entirely abated under present conditions.

## WALTHAM.

The careful precautions taken in regard to suspicious throat cases have been observed throughout the year. Cultures have been taken from all suspicious cases, at the request of the physician in charge, and quite a number of cases that would have passed as non-contagious were proved contagious and properly isolated.

No case of diphtheria has been let out of quarantine until a bacteriological test of the throat has proved the absence of the diphtheria bacillus. During the year 605 cultures have been taken, and the result of the bacteriological examination communicated to the physician in charge. The bacteriological laboratory of the Waltham Hospital has continued to serve the city by freely accommodating the board of health. There were 115 cases of diphtheria during the year, with 3 deaths, giving a very low mortality rate, which remarkable result was evidently due to the beneficial action of antitoxin, and also to the many mild cases which might have passed unnoticed but for the bacteriological test.

At the beginning of the present year this board notified the physicians of Waltham that free examinations of sputum for the bacilli of tuberculosis would be made by the physician of the board. As a result 52 specimens of sputum were sent to the board, and a careful microscopic examination made. The board also offered to disinfect after the death or removal of cases of consumption, when requested to do so by the physician in charge or the family.

In June, 1895, a somewhat different process of disinfection of rooms and furniture was begun. Reliance is no longer placed in fumigation, but in the most painstaking cleansing of every part of the room and furniture. Five per cent. solution of carbolic acid is used as a germicide. The city is in great need of a disinfecting station, where clothing and bedding can be disinfected by dry or superheated steam.

## WATERTOWN.

For the first time the care of all sanitary matters, which includes the bath-house, was assumed by the board of health. It was thought wise in the management of the bath-house to reserve it two afternoons a week for the use of women. For that purpose a woman was appointed to take charge of the bath-house during those afternoons. The plan has worked well and will be continued.

During the year the connection of all available premises with the common sewer has progressed very favorably. At every meeting of the board of health a number of premises have been ordered to be connected with the sewer, and almost uniformly the requests of the board have been complied with.

## WESTFIELD.

One hundred and eighty-nine nuisances have been abated during the year. Fifteen water-closets so located as to be considered nuisances have been ordered connected with the sewer.

We feel that the time has fully come when responsible persons should be employed to remove garbage from the streets and yards at least three times a week during the warm season.

## WESTFORD.

The use of antitoxin both as a cure and preventive of diphtheria has come into prominence and considerable use. We have been able to arrange for a supply from the State Board of Health through the city of Lowell, and in all necessary cases it can be used. Five patients have been treated with it during the year, with the following results: 2 cases membranous croup (diphtheritic), 1 recovery; 1 case diphtheria, recovery; 2 cases as a preventive, successful.

## WHITMAN.

During the past year seventy-three complaints were entered and attended to, thirty-six quarantine cards posted, and many other calls made and places investigated where no complaints have been made.

The row of dwelling-houses on Park Avenue, back of which lies Hobart's Pond, were nearly all found to be emptying their sink waste and sewage directly into the pond. Such a condition is in direct opposition to the laws of the State as well as public safety, hence the nuisance was discontinued.

## WOBURN.

The use of antitoxin was introduced and supplied free of charge to physicians who wished to use it in their practice. Its use has become general in Woburn, and the results are very satisfactory to the board. There is no doubt in the minds of the members of the board of health that its timely use has prevented an alarming death rate from diphtheria in Woburn during the last four months of the year.

## WORCESTER.

Number of complaints for the year ending Dec. 31, 1895, 1,602.

Nearly seven hundred cultures have been examined during the year, showing how largely physicians have availed themselves of the use of this department.

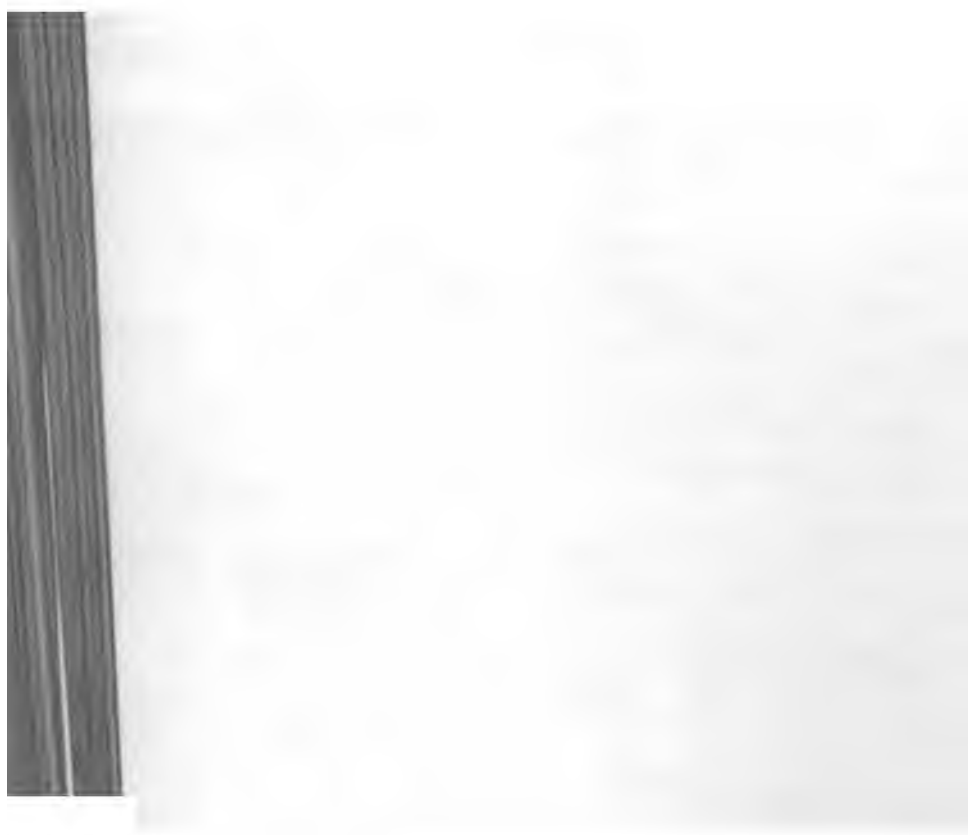
The city council selected and purchased a lot for an isolation hospital.

The office of the board is now open every day in the year; the hours Sundays and holidays are between 12 and 1 P.M. It was found necessary to make this addition to the office hours in order that the undertakers should be subjected to no delay in procuring burial permits, and also that culture tubes for diphtheria might be provided for and received from physicians.

The following group of figures presents the general death rate per 1,000, and the combined death rate per 10,000, from scarlet fever, diphtheria and croup, typhoid fever, cholera infantum and consumption, in a group of contiguous towns lying mostly in the metropolitan district, and for a period of four years, 1891-94. None of the number had a general death rate of more than 20 per 1,000, and the mean annual death rate of the group was 17.1 per 1,000 of the estimated living population.

*Four Years (1891-94).*

|                                       | General<br>Death Rate<br>per 1,000. | Death Rate<br>from Infectious<br>Diseases. |
|---------------------------------------|-------------------------------------|--------------------------------------------|
| Reading, . . . . .                    | 15.9                                | 2.7                                        |
| Stoneham, . . . . .                   | 14.8                                | 3.4                                        |
| Melrose, . . . . .                    | 15.1                                | 3.6                                        |
| Wakefield, . . . . .                  | 16.7                                | 3.8                                        |
| Malden, . . . . .                     | 17.1                                | 3.8                                        |
| North Reading, . . . . .              | 19.0                                | 4.1                                        |
| Laugus, . . . . .                     | 19.8                                | 4.2                                        |
| Voburn, . . . . .                     | 19.5                                | 4.5                                        |
| Synnfield, . . . . .                  | 17.1                                | 5.9                                        |
| Mean rate for the district, . . . . . | 17.1                                | 3.8                                        |



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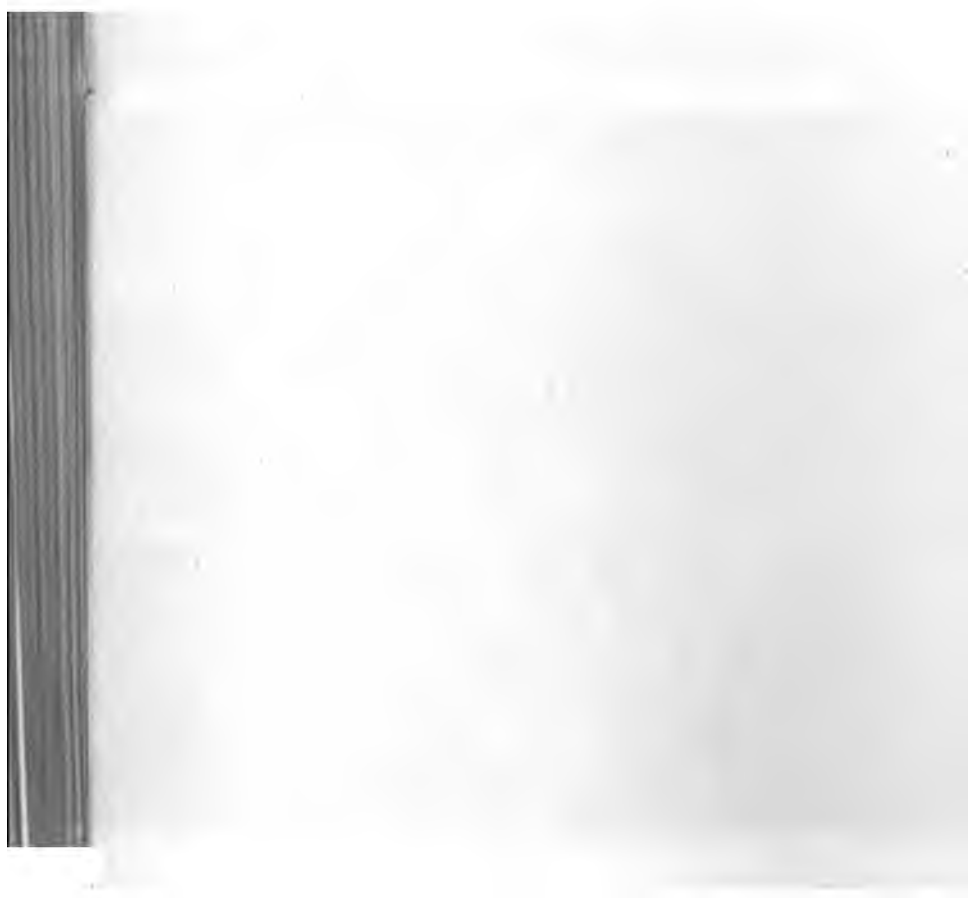
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